



Goal relevance shapes the behavioral impact of facial emotions: A meta-analysis

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ABSTRACT

Emotionally charged stimuli can significantly influence behavior, yet it remains unclear why they do so in some contexts but not in others. A growing body of evidence provides strong empirical evidence that the impact of emotional stimuli depends on their relevance to current task demands. This perspective challenges earlier views proposing automatic behavioral responses to emotional stimuli and complements contemporary accounts emphasizing privileged emotional processing by suggesting that emotional information influences behavior primarily when it is relevant to current goals. To assess this account, we conducted a PRISMA-compliant meta-analysis, examining how emotional facial expressions influence reactive inhibitory control in the Stop-Signal and Go/No-Go task (indexed by stop-signal reaction time and commission errors, respectively) and response readiness in the Go/No-Go task (indexed by reaction times and omission errors) in healthy young adults, as a function of goal relevance. Goal relevance was tested as a categorical moderator across emotional contrasts and behavioral outcomes. Results showed that emotional valence reliably modulated inhibitory control and response readiness when emotional information was required for response selection but produced little or no systematic behavioral effects when it was task-irrelevant. Within-subject studies yielded the most robust effects, likely reflecting greater statistical power and reduced inter-individual variability. No consistent evidence of publication bias was detected. These findings support a goal-directed account of emotion–action interactions and suggest that enhanced neural processing of emotional stimuli does not necessarily translate into behavioral effects. Rather, emotional information appears to influence action primarily when it is relevant to the current goals.

1. Introduction

One striking aspect of emotion research is the considerable variability in empirical findings. This inconsistency is disorienting and hinders the development of a unified understanding of how emotions influence behavior. Over the past 25 years, influential theories have proposed that emotionally salient stimuli enjoy a privileged status in information processing, such that they can attract attention and influence behavior even when they are unrelated to an individual's current goals (Bradley et al., 2001; Vuilleumier, 2005). Consequently, even when such stimuli are irrelevant to an individual's goals, if they are sufficiently arousing, they elicit rapid and automatic behavioral responses believed to help organisms cope with important life tasks and increase the likelihood of survival and reproduction. This idea is central to evolutionary approaches, including the motivational model (Bradley

et al., 2001; Lang and Bradley, 2010; Lang et al., 1997). According to this model, positively valenced stimuli activate an appetitive motivational system that promotes behaviors such as eating, mating, and caregiving. In contrast, negatively valenced stimuli activate a defensive motivational system, leading to behaviors such as withdrawal, escape, freezing, or aggression. An influential extension of this framework, the motivational direction hypothesis (or approach-avoidance hypothesis), predicts the direction of action in response to emotional stimuli: positive-valence stimuli activate the appetitive system and tend to prompt movement toward the stimulus, whereas negative-valence stimuli engage the defensive system and are expected to prime avoidance behaviors (Chen and Bargh, 1999; Duckworth et al., 2002; Lang et al., 1997). While both models allow some flexibility in responses, this flexibility is largely determined by stimulus properties, such as arousal. Highly arousing stimuli elicit stronger responses, whereas low-arousing

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ones lead to weaker reactions. Crucially, in these models, flexibility is assumed to arise primarily from the properties of the stimuli, rather than from the individual's current goals.

Although intuitively appealing, this view is not consistently supported by empirical evidence and has thus been reformulated. Contemporary frameworks increasingly conceptualize emotional processing as emerging from dynamic interactions among emotion, attention, motivation, and cognitive control systems rather than from a dedicated automatic pathway (Pessoa, 2009; Pessoa and Adolphs, 2010). Consistent with this perspective, influential frameworks derived from the biased competition model of attention (Desimone and Duncan, 1995) suggested that emotional stimuli may acquire a competitive attentional advantage because of their affective significance, but that this advantage is also shaped by attentional demands and top-down control (Blair and Mitchell, 2009; Pessoa and Ungerleider, 2004; Pourtois et al., 2013). Consistent with these accounts, neuroimaging studies have shown that increasing attentional demands can attenuate or even eliminate neural responses to task-irrelevant emotional stimuli (Ishai et al., 2004). Similarly, the perceptual load theory (Lavie, 2005) predicts reduced processing of task-irrelevant emotional stimuli under conditions of high perceptual load. Importantly, these accounts maintain the core assumption that emotional stimuli have a privileged status, and thus engage neural systems that bias perceptual processing and increase their competitive strength. However, these frameworks primarily address how emotional processing is modulated by attentional allocation and available resources. They do not directly address the related but distinct question of whether the behavioral impact of emotional information depends on whether it is required for response selection. Specifically, they do not identify which task-related factors determine when emotional information wins the competition for behavioral control. One candidate factor is goal relevance, namely, whether emotional information is required for selecting an appropriate response. Accordingly, the unresolved issue is not whether emotional stimuli are processed, but under which conditions such processing translates into measurable behavioral effects.

Recent evidence suggests that a critical factor gating behavioral reactions to emotional stimuli may be the relationship between emotional information and an individual's current goals. A systematic review (Mirabella and Montalti, 2025) and a meta-analysis (Maxwell et al., 2025) reported that facial expressions influence motor responses more reliably when emotional information is relevant to an individual's current goals than when it is incidental to them. This distinction helps explain how people function effectively in emotionally rich environments. For instance, a traveler moving through a crowded airport terminal is surrounded by faces conveying a wide range of emotions, yet the traveler is typically able to pursue goal-directed behavior without being continuously distracted by them. More generally, identical emotional cues can elicit markedly different responses depending on situational demands, social roles, and prior experience. Such flexibility indicates that emotional stimuli interact with higher-order control processes that prioritize behavior in accordance with current goals and contextual constraints.

Evidence consistent with this view has emerged across a variety of experimental domains. Hunt et al. (2007) and Devue and Grimshaw (2017) investigated the impact of task-irrelevant schematic and real emotional faces, respectively, in visual search tasks. Both studies reported that the presence of task-irrelevant distractor faces led to prolonged saccadic reaction time (RT) and decreased accuracy relative to distractor-absent conditions, whereas the valence of the emotional expressions exerted no significant effect on eye-movements. Similarly, Stein et al. (2009), Lichtenstein-Vidne et al. (2012), and Victeur et al. (2020) employing the attentional blink task, Eriksen flanker test, and a matching task, respectively, demonstrated that emotional faces fail to capture attention when deemed task-irrelevant. Comparable findings have been reported in other cognitive domains. Berger et al. (2017) demonstrated that emotional valence influenced working memory

performance when the emotional information was task-relevant but not when it was task-irrelevant. Specifically, positive facial expressions enhanced working memory, resulting in higher accuracy and faster RT for happy faces than for neutral or angry faces. Likewise, Mauersberger et al. (2024) showed that emotional mimicry depended on participants' goals, emerging only for faces whose emotional expressions they were required to categorize. Although suggestive, the role of goal relevance is difficult to interpret because it was not manipulated independently of other methodological factors, leaving open the possibility that the reported effects were driven by confounding variables.

Stronger evidence comes from a series of within-subject studies that directly manipulated the goal relevance of emotional information while keeping the physical stimuli constant. These studies compared two versions of the same Go/No-Go paradigm (GNG): the Emotion Discrimination Task (EDT), in which emotional information was necessary for providing a correct response, and the Control Discrimination Task (CDT), in which the same emotional stimuli were presented but responses were based on non-emotional features such as gender or shirt color. This design provides a particularly stringent test because the emotional stimuli, participants, and experimental context remain identical across conditions; only the relevance of emotional information for response selection changes.

The EDT-CDT paradigm has been used to investigate different aspects of motor control, such as response readiness (Mancini et al., 2020; Mirabella, 2018; Mirabella et al., 2024a; Mirabella et al., 2023; Mirabella et al., 2024b; Montalti and Mirabella, 2023, 2024) and reactive inhibitory control¹ (Calbi et al., 2022; Mancini et al., 2022); as well as different movement types, including reaching arm movements (Mancini et al., 2020, 2022; Mirabella, 2018; Montalti and Mirabella, 2023, 2024), keypresses (Calbi et al., 2022; Mirabella et al., 2024b), eye movements (Mirabella et al., 2024a), and lower limbs (Mirabella et al., 2023). Different emotional stimuli have also been employed, ranging from facial expressions (Mancini et al., 2020, 2022; Mirabella, 2018; Mirabella et al., 2024b; Montalti and Mirabella, 2023, 2024) to body-posture expressions (Calbi et al., 2022). Across these studies, task-relevant unpleasant expressions (angry or fearful) produced distinct effects depending on the cognitive process under investigation. When acting as go-signals, they slowed responses and increased omission errors (OE) relative to pleasant (happy) expressions, indicating reduced response readiness (e.g., Mirabella et al., 2024a; Montalti and Mirabella, 2023; Montalti and Mirabella, 2024). In contrast, when acting as no-go signals, they reduced commission errors (CE), indicating enhanced inhibitory control (Calbi et al., 2022; Mancini et al., 2022). No such differences emerged in task-irrelevant contexts. The authors explained these results by suggesting that, when task-relevant, unpleasant expressions delay attentional disengagement, as individuals tend to monitor potential threats more closely than positive stimuli, thereby slowing action initiation while enhancing inhibitory control. Thus, task-relevant negative emotional stimuli did not exert uniformly disruptive effects; rather, their influence depended on the cognitive operation being measured, impairing response readiness while facilitating inhibitory control.

Importantly, these findings do not imply that emotional stimuli fail to elicit rapid or automatic neural processing (Carretié et al., 2021). On the contrary, neuroimaging evidence indicates that emotional stimuli can engage dedicated neural systems even when they do not produce measurable behavioral consequences (Gur et al., 2002b; Mirabella et al., 2024b; Sagaspe et al., 2011). For instance, Mirabella et al. (2024b), using functional magnetic resonance imaging, identified a network of brain regions exhibiting distinct activation patterns in response to

¹ Inhibition is not a unitary construct; the literature converges on the existence of two neuropsychological domains: (1) reactive inhibition, which is the ability to respond to a stop signal, and (2) proactive inhibition, which is the ability to modulate reactive inhibition in advance according to one's goals.

identical facial emotional expressions when presented in the EDT versus the CDT. They argued that such neural activity may integrate internal representations of task rules with the sensory features of facial expressions, thereby enabling the appraisal of an emotional stimulus within a given context and guiding behavioral responses only when that stimulus is relevant to an individual's current goals. The crucial issue, therefore, is not whether emotional information is processed, but whether such processing is sufficient to influence overt behavior under different task conditions.

Despite growing evidence supporting goal-relevance accounts, the available findings have been obtained using different paradigms, making it difficult to isolate the specific contribution of goal relevance to emotional influences on behavior. Consequently, it remains unclear whether emotional stimuli influence behavior primarily when they are relevant to current goals, or whether the apparent inconsistencies in the literature instead reflect methodological variability and publication bias. A quantitative synthesis is therefore needed to clarify these issues.

1.1. Purpose of the current meta-analysis

Although a previous review supported the view that goal-relevance plays a pivotal role in modulating behavioral responses to emotional stimuli (Mirabella and Montalti, 2025), several methodological and conceptual shortcomings of the reviewed papers substantially limited the interpretability of those conclusions. Many studies did not control for stimulus arousal, making it difficult to disentangle valence effects from those driven by arousal intensity. The absence of reported effect sizes and the omission of Bayesian analyses in the literature reviewed further hinder the assessment of effect robustness and the distinction between true null results and inconclusive findings. In addition, frequent reliance on small samples reduced statistical power, increasing the likelihood of both false positives and false negatives, while the rare use of within-subject designs limited control over inter-individual variability. Collectively, these issues offer an inconsistent and potentially biased picture, weakening theoretical conclusions about the role of goal-relevance in emotional processing. Given these limitations, a qualitative synthesis alone cannot resolve the inconsistencies in the literature, as it cannot quantify the magnitude or reliability of the observed effects. A meta-analytic approach, in contrast, can integrate effect sizes across studies, weighting them by their precision, yielding more precise estimates of the behavioral impact of emotional stimuli. Although most available studies examine only one level of goal-relevance, focusing exclusively on either goal-relevant or goal-irrelevant stimuli, this does not preclude meta-analysis: effect sizes can be extracted separately for each category, pooled, and compared statistically by treating goal-relevance as a categorical moderator.

The present meta-analysis focuses on how healthy young adults respond to facial emotional stimuli, deliberately restricting the scope to externally presented emotions rather than internally generated ones. Goal relevance was operationalized according to whether the emotional content of a stimulus was required to select the correct response. Emotional stimuli were classified as goal-relevant when participants had to use the displayed emotion to perform the task correctly (e.g., when the instruction was to respond differently to emotional versus neutral facial expressions, or to different emotional expressions). Conversely, stimuli were classified as goal-irrelevant when responses could be selected based on non-emotional features of the stimulus, such as gender or age, regardless of the emotional expression shown (e.g., when the instruction was to respond to male faces and withhold responses to female faces, irrespective of their emotional expression). Thus, goal relevance was determined by the information required for response selection, rather than by the physical presence or visibility of the emotional stimulus, or by whether attention was directed toward it.

Because the present work is concerned with how emotional information influences overt behavioral responses rather than perceptual processing per se, we focused on paradigms that provide well-

established measures of action control and response selection. Specifically, we focused on studies examining response readiness and inhibitory control using the GNG (Donders, 1969) and inhibitory control using the Stop-Signal Task (SST; Logan et al., 1984), building on previous research in this area (see Figure S1 for a schematic of the tasks). The tasks assessed two different types of inhibition: the SST assesses the ability to suppress an ongoing response (action cancellation), whereas the GNG evaluates the ability to inhibit a potential action before its execution (action restraint; see Supplemental Methods for further details). In addition, when emotional stimuli serve as go signals, the GNG can be used to assess response readiness (the SST paradigm does not provide a comparable measure of response readiness because, commonly, a staircase procedure is used to maintain stopping performance around 50%). Consequently, although both paradigms are widely used to study inhibitory control, they engage partially distinct cognitive mechanisms and should not be considered interchangeable measures of inhibition (Littman and Takács, 2017). These tasks, despite minor adaptations to address specific experimental questions, maintain the core experimental design, produce relatively consistent behavioral outcomes, and, given their widespread use, offer a substantial body of work to analyze. We included only studies with healthy young adults (18–35 years) that used real human facial expressions and hand/arm responses, to ensure developmental stability and minimize variability in visual features. We excluded studies involving brain stimulation, mindfulness interventions, internal triggers, or lacking behavioral data, retaining only those with direct, comparable behavioral measures to maximize methodological homogeneity across studies.

Importantly, a meta-analytic approach provides quantitative estimates, detects potential publication bias, and more rigorously evaluates the predictions of goal-relevance accounts. Should our hypothesis that goal-relevance plays a central role in shaping behavioral responses to emotional stimuli be supported, the implications would be both theoretical and practical. In particular, it would suggest that the widespread use of task-irrelevant emotional stimuli in experimental paradigms may provide only limited insights into the factors that determine whether emotional stimuli influence behavior.

2. Methods

2.1. Transparency and openness

This meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Page et al., 2021). All data, analysis code, and research materials (including our coding scheme) are available at https://osf.io/vn7p5/overview?view_only=b92e9c8d31bc417b92600556251dbda2. Analyses were conducted using Comprehensive Meta-Analysis, Version 4 (Borenstein, 2022) and R (version 4.5.2; R Core Team, 2025). The protocol for this review was not preregistered, reflecting the retrospective nature of the literature synthesis; however, all inclusion criteria and analytic decisions were defined a priori and applied consistently across studies.

Ethics statement: This study is a meta-analysis based solely on previously published data and therefore did not require approval from an institutional review board or ethics committee.

2.2. Literature search and study selection

Systematic literature searches were conducted on March 19, 2025. Six electronic databases, PubMed (<https://www.ncbi.nlm.nih.gov/pubmed/>), Scopus (www.scopus.com/), Business Source Premier (via EBSCOHost, <https://search.ebscohost.com/>), APA PsycINFO (via EBSCOHost), MEDLINE (via EBSCOHost) and Psychology and Behavioral Sciences Collection (via EBSCOHost), were searched for studies involving healthy young adults that employed either the SST or the GNG. No restrictions were placed on publication date, but only fully

published articles in English were included.

Keywords combined terms related to emotion, facial expressions, and the specific inhibitory control task. Search strategies were adapted to the syntax requirements of each database; the complete database-specific search strings are provided in the [Supplemental Materials](#).

2.3. Eligibility criteria

Studies were selected according to the inclusion/exclusion criteria detailed below.

2.3.1. Inclusion criteria

Studies should:

- a) Employ validated static photographs of real faces depicting at least two facial expressions, including a neutral expression and/or one or more of the six basic emotions (i.e., sadness, happiness, fear, anger, surprise, and disgust);
- b) Include healthy participants aged between 18 and 35 years to ensure sample homogeneity and minimize potential confounding effects related to age (Charles and Carstensen, 2010; Ruffman et al., 2008). Young adults drawn from lifespan studies on healthy populations and healthy control groups from clinical studies were also considered;
- c) Include experimental groups comprising more than 15 participants. This threshold was defined a priori by the authors to reduce the influence of very small samples, which may yield unstable estimates and increased inter-individual variability, while retaining a sufficient number of studies for quantitative synthesis.
- d) Include behavioral measures related to emotional stimuli [e.g., stop-signal reaction time (SSRT), RT, OE, CE], together with their corresponding statistical analyses. Studies focusing exclusively on signal detection theory were excluded;
- e) Employ the hand or arm as response effectors;
- f) Report the mean and standard deviation (SD) of the primary behavioral measures, or provide an index of mean change (e.g., Cohen's d , Hedges' g , t -test with p -value, or F -test) directly comparing two conditions (e.g., neutral vs. negative faces, neutral vs. positive faces, or positive vs. negative faces), along with the number of participants included in the analyses. Studies for which sufficient data could not be obtained were excluded;
- g) Be published in English in international peer-reviewed journals.

2.3.2. Exclusion criteria

Studies should not:

- a) Employ non-validated stimuli, such as images sourced from the internet, personal collections, or photographs of laboratory members. Studies using schematic, morphed, or computer-generated faces were also excluded, as these differ from real faces in their ability to convey emotions;
- b) Include only patients or individuals with high trait anxiety;
- c) Involve eye movements or lower limb responses, which are controlled by partially distinct neural and biomechanical systems compared with upper-extremity effectors. Restricting the analysis to upper-limb responses was intended to reduce methodological heterogeneity arising from differences in movement dynamics, energetic costs, and movement vigor across effectors (Shadmehr and Ahmed, 2020).
- d) Involve brain stimulation techniques (e.g., transcranial magnetic stimulation or transcranial direct current stimulation) or treatments that alter brain functioning (e.g., hypnosis, mindfulness, sleep deprivation, hormones, drugs). This decision aims to maintain a focus on the natural processing of emotions without external interference. However, data from healthy control groups (e.g., placebo or sham conditions), when available, were included;

- e) Fail to provide sufficient information on behavioral measures involving emotional stimuli, or reported only d' and β as accuracy indices, and the authors did not respond to request for additional data;
- f) Be conference papers, systematic reviews, and meta-analyses.

The retrieved papers were appraised to exclude those that did not meet the inclusion and exclusion criteria based on title, keywords, abstract, or full-text screening. Duplicate removal and the selection process were performed using Rayyan, a web-based systematic review screening tool (<https://www.rayyan.ai>, Ouzzani et al., 2016). Any discrepancies in study evaluation were resolved through discussion among the authors.

2.4. Study quality assessment

All included studies employed observational, analytical, cross-sectional designs. Methodological quality was therefore evaluated using the Joanna Briggs Institute (JBI) Critical Appraisal Tool for Analytical Cross-Sectional Studies (Moola et al., 2020). This tool consists of eight criteria assessing key methodological domains, including sample selection, measurement validity and reliability, identification and control of confounding variables, and the appropriateness of statistical analyses (see Table S1 in the [Supplemental Material](#)).

Although the JBI checklist was originally developed for qualitative appraisal, a structured numerical scoring system was applied to facilitate standardized comparison across studies. Following the operational definitions detailed in the [Supplemental Material](#), each item was scored on a scale from 0 to 2, with higher scores indicating greater compliance with the criterion. Scores were derived using a predefined deduction procedure, in which each item was initially assigned a maximum score of 2 points and points were subtracted based on specific methodological shortcomings. Intermediate scores in 0.5-point increments reflected partial fulfillment of a criterion. Items judged as not applicable were excluded from scoring. An overall quality score was calculated for each study by summing the scores across all applicable items and dividing by the maximum possible score for that study (i.e., 16 when all eight items were applicable), yielding a normalized quality score. This normalization does not alter item-level judgments but rescales study-specific totals to a common metric, thereby enabling comparability across studies despite differences in item applicability. Studies scoring above 80% were classified as high-quality and unbiased; those scoring between 66% and 80% as satisfactory and not substantially biased; and those scoring between 51% and 65% as moderate-to-low quality and potentially biased. Studies with scores $\leq 50\%$ were excluded from further analyses.

2.5. Data extraction

For each included paper, information was extracted on:

- a) participants' characteristics, including sample size, gender distribution, and mean age;
- b) study design features, including task characteristics, stimulus properties, and methods of arousal assessment;
- c) behavioral outcome measures related to emotional stimuli. Because the SST and GNG assess partially distinct forms of inhibitory control, outcomes were extracted and analyzed separately for each paradigm. For the SST, the primary outcome was the SSRT, which indexes the speed of action cancellation following the presentation of a stop signal. For the GNG, extracted measures included RT for correct go trials and OE, both indexing response readiness, and CE, which reflects inhibitory control through the restraint of a prepotent response.

For each emotional condition, the means and SD of the primary behavioral measures were extracted when available. When studies reported multiple negative emotional conditions (e.g., fearful, angry, sad),

means and SD were combined across these conditions within each study using standard procedures for dependent measures (accounting for within-study correlations among conditions) to yield a single estimate per valence category (see [Supplemental Materials](#) for details). When descriptive statistics were not reported, inferential statistics (i.e., t values with associated p values or F statistics for contrasts between emotional conditions) were extracted. If only standard errors (SE) were reported, they were converted to SD using the formula $SD = SE * \sqrt{n}$, where n is the number of participants (DeVellis, 1991). When numerical data were not provided in the text or tables, values were extracted from published figures using WebPlotDigitizer (<https://automeris.io/WebPlotDigitizer/>). If data could not be obtained using these methods, the corresponding authors were contacted to request the missing information.

Finally, based on the extracted task characteristics, studies were subsequently coded as goal-relevant or goal-irrelevant according to the operational definition provided in the Introduction.

2.6. Data synthesis and statistical analysis

Effect sizes (standardized mean differences; SMD) and corresponding sampling variances were computed using the algorithms implemented in Comprehensive Meta-Analysis (version 4, Borenstein, 2022). Hedges' g was used as the standardized effect size measure because it corrects for small sample bias (Lakens, 2013). When available, means and SD of behavioral measures for each emotional condition were used to compute effect sizes. If studies reported only t - or F -values for contrasts between emotional conditions, these statistics were converted into Hedges' g using standard transformation procedures implemented in the software.

Primary two-level random-effects models were estimated in Comprehensive Meta-Analysis for each emotional valence contrast $\times$ outcome combination. Multilevel moderator analyses were subsequently conducted in R (version 4.5.2; R Core Team, 2025) using the *metafor* package (Viechtbauer, 2010) to account for dependent effect sizes arising from within-subject designs (see paragraph 2.7).

In all studies included in the meta-analysis, the same participants responded to all emotional conditions. For each comparison, the mean difference (MD) between emotional conditions was first computed as:

$$MD = M_2 - M_1$$

The standard deviation of the paired difference (SD_{Δ}) was calculated as:

$$SD_{\Delta} = \sqrt{SD_1^2 + SD_2^2 - 2r SD_1 SD_2}$$

where r represents the within-subject correlation between conditions. Because most primary studies did not report the within-subject correlation, a value of $r = 0.5$ was assumed, consistent with recommendations in the meta-analytic literature (Borenstein et al., 2009; Morris and DeShon, 2002). Sensitivity analyses were conducted using $r = .30$ and $r = .70$ to evaluate the robustness of the results (see [Table S2](#) in the [Supplemental Materials](#)). Sampling variances incorporate the assumed within-subject correlation and therefore vary with the assumed value of r .

The standardized mean difference for paired observations (d) was then obtained as:

$$d = \frac{MD}{SD_{\Delta}}$$

To correct for small-sample bias, Hedges' g was computed by applying the correction factor (J):

$$g = Jd$$

where

$$J = 1 - \frac{3}{4df - 1}$$

with $df = n - 1$.

The sampling variance of the paired standardized mean difference was computed as:

$$Var(d) = \left(\frac{1}{n} + \frac{d^2}{2n} \right) * 2(1 - r)$$

and the variance of Hedges' g was obtained as:

$$Var(g) = J^2 Var(d)$$

Standard errors were calculated as:

$$SE_g = \sqrt{Var(g)}$$

Separate meta-analytic models were estimated for each emotional contrast (neutral vs. negative, neutral vs. positive, positive vs. negative) and for each behavioral outcome (SSRT, RT, OE, CE). Within each model, goal-relevance was tested as a categorical moderator when applicable. Each estimate, therefore, reflects a distinct and analytically independent model corresponding to a specific emotional valence contrast $\times$ outcome condition, with moderator effects evaluated within that framework.

Between-study heterogeneity was evaluated for each meta-analytic model using three complementary indices. First, Cochran's Q statistic was computed to test whether the observed dispersion in effect sizes exceeded that expected under sampling error alone. Under the null hypothesis of homogeneity, Q follows a chi-square distribution with $k-1$ degrees of freedom (Higgins and Thompson, 2002). Because Q is sensitive to the number of included studies, it was interpreted alongside descriptive heterogeneity indices.

Second, the I^2 statistic was calculated to quantify the proportion of total observed variance attributable to between-study heterogeneity rather than sampling error (Higgins et al., 2003). Values of approximately 25%, 50%, and 75% were interpreted as low, moderate, and high heterogeneity, respectively, while recognizing that I^2 is a relative measure influenced by study precision (Borenstein et al., 2017).

Third, τ^2 was estimated using the DerSimonian-Laird method (DerSimonian and Laird, 1986) method as an absolute index of between-study variance in true effect sizes. Unlike I^2 , τ^2 is expressed in squared effect size units and directly determines study weights under the random-effects model.

Given the anticipated conceptual and methodological variability across studies (e.g., task structure, stimulus characteristics, arousal control, and sample composition), a random-effects framework was adopted for all analyses. Under this model, true effect sizes are assumed to vary across studies and to follow a distribution with mean μ and variance τ^2 (Borenstein et al., 2009). Accordingly, pooled estimates represent the mean of the distribution of true effects rather than a single common effect size.

2.7. Subgroup analysis

Moderator analyses were conducted to test the central hypothesis that goal-relevance systematically moderates the impact of emotional stimuli on behavioral performance. Goal-relevance (goal-relevant vs. goal-irrelevant) was modeled as a categorical moderator within mixed-effects meta-analytic models.

Because within-subject designs involve multiple effect sizes derived from the same studies (i.e., goal-relevant and goal-irrelevant conditions completed by the same participants), a three-level random-effects meta-analytic model was specified, with effect sizes nested within studies. This approach accounts for statistical dependence among effect sizes and

permits the simultaneous estimation of condition-specific effects within a unified analytic framework. The model was estimated using restricted maximum likelihood (REML). Condition was included as a fixed-effect moderator to directly compare goal-relevant and goal-irrelevant emotional conditions. The significance of the moderator was evaluated using the omnibus test of moderators, which tests whether the regression coefficient associated with goal-relevance differs from zero.

2.8. Sensitivity analysis: leave-one-out procedure

To examine the robustness of the meta-analytic findings, sensitivity analyses were conducted using the leave-one-out procedure. In this approach, the random-effects model is iteratively re-estimated while excluding one study at a time, and the pooled effect size, confidence interval, and heterogeneity estimates are recalculated at each step (Willis and Riley, 2017). This procedure evaluates the stability of the overall effect and identifies studies that exert disproportionate influence on pooled estimates, between-study heterogeneity, or model significance. A study was considered influential if its removal substantially reduced heterogeneity, markedly altered the magnitude or direction of the pooled effect size, or changed the statistical significance of the model. In such cases, the study was carefully examined for methodological or statistical anomalies (e.g., extreme variance estimates or outlying effect sizes) and, when justified based on predefined criteria, excluded from the final model to improve the robustness and interpretability of the estimates. All exclusions and their impact on pooled effects are described transparently in the Results section. When influential studies were excluded according to predefined criteria, the corresponding final pooled estimates are reported in summary tables and figures. This reporting convention was applied consistently across all contrasts and outcomes.

2.9. Assessment of publication bias

Publication bias refers to the distortion of meta-analytic estimates arising from the underreporting of non-significant findings or other small-study effects (Sterne et al., 2001; Thornton and Lee, 2000). Risk of bias was evaluated through visual inspection of funnel plots (Sterne and Egger, 2001) and formally tested using Egger's regression test (1997) and Begg and Mazumdar's rank correlation test (1994).

Egger's test evaluates funnel plot asymmetry by regressing standardized effect sizes on study precision (the inverse of standard error). In the absence of small-study effects, the intercept is expected to equal zero. The rank correlation test evaluates the association between effect sizes and their sampling variances using a nonparametric approach (Lin and Chu, 2018). Because these procedures rely on different assumptions (linear vs. monotonic associations between effect size and precision), they provide complementary evidence regarding potential funnel plot asymmetry (Borenstein et al., 2009; Higgins et al., 2023; Sterne et al., 2011). Egger's test is generally more powerful but sensitive to heterogeneity and outliers, whereas the rank correlation test is more conservative. Converging results across methods were interpreted as stronger evidence of small-study effects; discrepancies were interpreted cautiously in light of sample size and heterogeneity.

Where asymmetry was detected ($p < .05$), the trim-and-fill procedure (Duval and Tweedie, 2000) was applied as an exploratory sensitivity analysis to estimate the number of potentially missing studies required to restore funnel plot symmetry and to compute an adjusted pooled effect size. Given its reliance on distributional assumptions and sensitivity to between-study heterogeneity, results were interpreted cautiously (Sterne et al., 2011). Both the number of imputed studies and the magnitude of change between the original and adjusted pooled estimates were considered when evaluating the potential impact of asymmetry.

3. Results

3.1. Study selection

We conducted two separate searches: one for studies employing the SST and one for those using the GNG task. The same selection procedure was applied to both searches. After duplicate removal, studies were screened based on titles and abstracts, and potentially eligible articles underwent full-text review. The application of predefined inclusion and exclusion criteria yielded 53 studies for the present meta-analysis.

3.1.1. Study selection for the Stop-Signal Task

The SST search initially identified 258 records. After screening and eligibility assessment, 29 articles were reviewed in full text, of which 15 met the inclusion criteria (Fig. 1).

3.1.2. Study selection for the Go/No-Go task

The GNG search yielded 1748 records. Following screening procedures, 94 articles were assessed in full text, and 38 satisfied the inclusion criteria (Fig. 2).

3.1.3. Methodological quality assessment for Stop-Signal Task

The results of the methodological quality assessment for the SST studies ($n = 15$) are presented in Table 1 (for detailed evaluations, see Supplemental Materials). Two of the authors (GM, VM) independently assessed all 15 articles. They reached identical inclusion/exclusion decisions for 10 of the 15 studies (66.7%). Inter-rater reliability for the coding of study characteristics and outcomes was assessed prior to consensus discussions using unweighted Cohen's kappa (Cohen, 1960), calculated separately for each coding question; kappa values are reported in the final row of Table 1. All discrepancies in both study selection and coding were subsequently resolved through discussion, resulting in full consensus. All 15 studies were included: five (~33.3%) were rated as satisfactory quality and ten (~66.7%) as moderate-to-low quality. The individual independent evaluations from each reviewer are available at <https://osf.io/vn7p5/overview>.

3.1.4. Methodological quality assessment for Go/No-Go task

Table 2 presents the results of the methodological quality assessment for the GNG studies ($n = 38$). Two reviewers (GM and VM) independently assessed all 38 articles. They reached identical inclusion/exclusion decisions for 32 of the 38 studies (84.2%). Inter-rater reliability for the coding of study characteristics and outcomes was assessed prior to consensus discussions using unweighted Cohen's kappa (Cohen, 1960), calculated separately for each coding question; corresponding kappa values are reported in the final row of Table 2. All discrepancies were subsequently resolved through discussion, resulting in full consensus. Eleven studies were excluded based on methodological quality, i.e., quality rating total score $\leq 50\%$. Of the 27 retained studies, six were rated high quality (22.2%), two satisfactory (7.4%), and 19 medium–low quality (70.4%). Detailed justifications for individual appraisal items are provided in the Supplemental Materials. The individual independent evaluations from each reviewer are available at https://osf.io/vn7p5/overview?view_only=b92e9c8d31bc417b92600556251bdba2.

3.2. Methodological features of selected studies

Before presenting the meta-analytic findings, we summarize the principal methodological characteristics of the SST and GNG studies (see Tables 3 and 4). This overview contextualizes variability in task implementation and clarifies how emotional stimuli were embedded within experimental paradigms. We focus on two dimensions: (a) the functional role of emotional facial expressions within the task (i.e., whether they act as go-signal, stop-/no-go signal, or both), and (b) the goal-relevance of emotional valence.

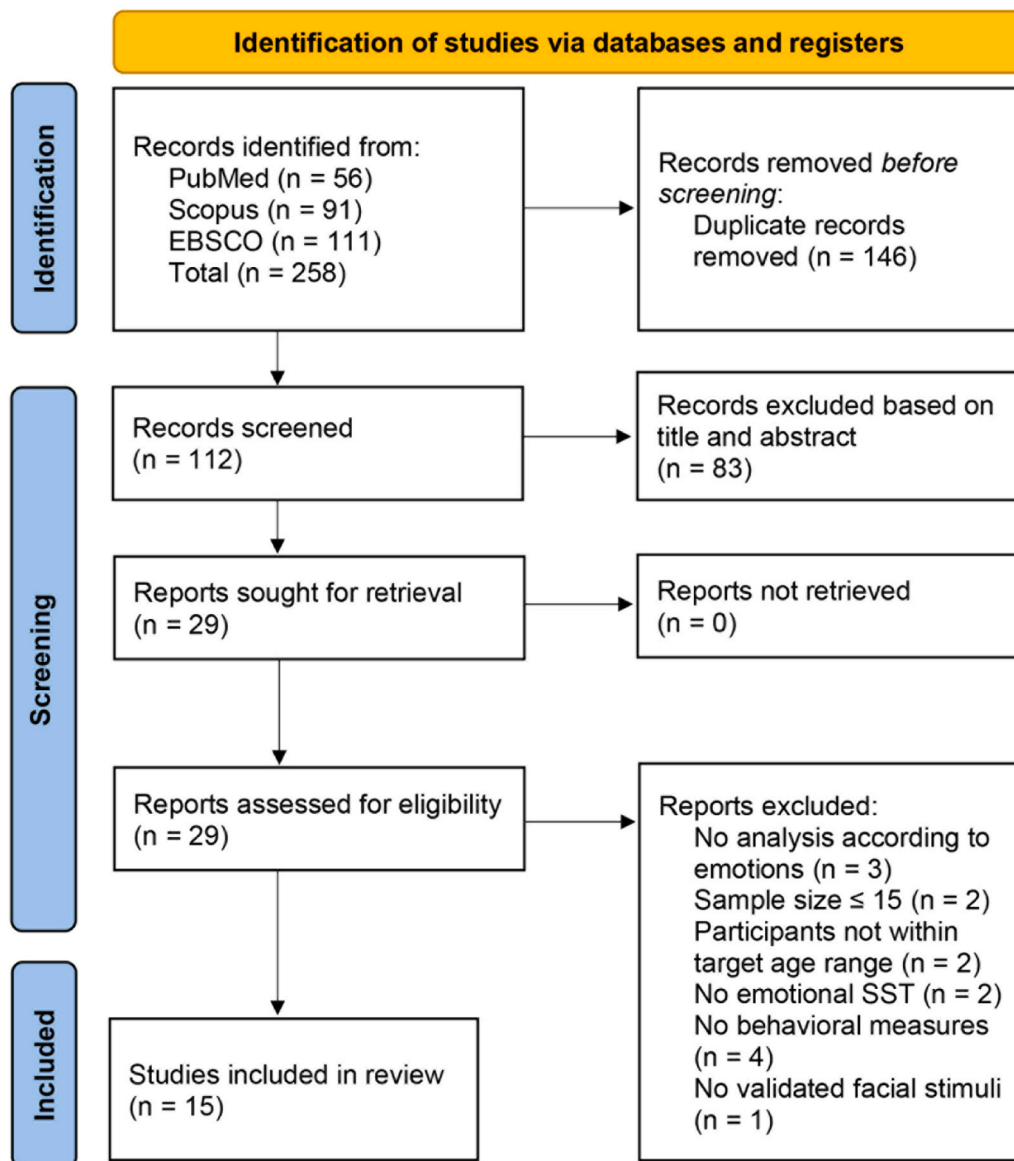


Fig. 1. Flowchart of the literature search and study selection process for Stop-Signal task studies conducted on March 19, 2025. The search was limited to English-language publications containing the keywords *emoti** <AND> (*face** <OR> *facial*) AND (*'stop signal'* <OR> *'countermanding'*) in the title or abstract, with no restrictions on publication date. After the initial screening of titles and abstracts, full-text articles were assessed against predefined eligibility criteria (see Section 2.3 for details). Fifteen articles met the inclusion criteria.

The functional role of emotional stimuli is theoretically important because the experimental rationale varies with how emotional information is integrated into the task structure. When emotional faces serve as go-signals, they are expected to modulate the go process, thereby indirectly influencing inhibitory performance. In contrast, when emotional faces function as stop-/no-go signals, they act as inhibitory cues and are hypothesized to directly affect the stopping process itself. When emotional stimuli serve both roles, they may simultaneously influence initiation and inhibition, increasing interpretative complexity. Although conceptually relevant, this dimension could not be modeled as a moderator in the quantitative analyses due to the limited number of studies within each category.

By contrast, goal-relevance of emotional valence was explicitly examined as a categorical moderator in all meta-analytic models. Specifically, behavioral outcomes (SSRT, RT, OE, CE) were compared across emotional contrasts (neutral vs. negative, neutral vs. positive, positive vs. negative), distinguishing between studies in which emotional valence was task-relevant and those in which it was incidental to task

goals. When studies reported multiple negative emotional conditions (e. g., fearful, angry, sad), these were aggregated to yield a single estimate per valence category (see Section 2.5). This decision was guided by dimensional and motivational models of affect, which conceptualize emotions as organized primarily along valence and arousal dimensions and as engaging broad appetitive versus defensive systems (Lang and Bradley, 2010). Within this framework, emotions sharing negative valence are assumed to recruit overlapping defensive motivational processes, which are hypothesized to exert broadly comparable influences on cognitive control (Pessoa, 2009). Aggregation at the valence level enabled theoretically coherent contrasts and preserved adequate statistical power for meta-analytic estimation.

3.2.1. Methodological features of selected Stop-Signal Task studies

As shown in Table 3, among SST studies, emotional faces were used nearly equally as stop-signals ($n = 7$) or as go-signals ($n = 6$), with only one study employing faces in both roles. One additional study used emotional expressions as primes preceding the go-signal and was

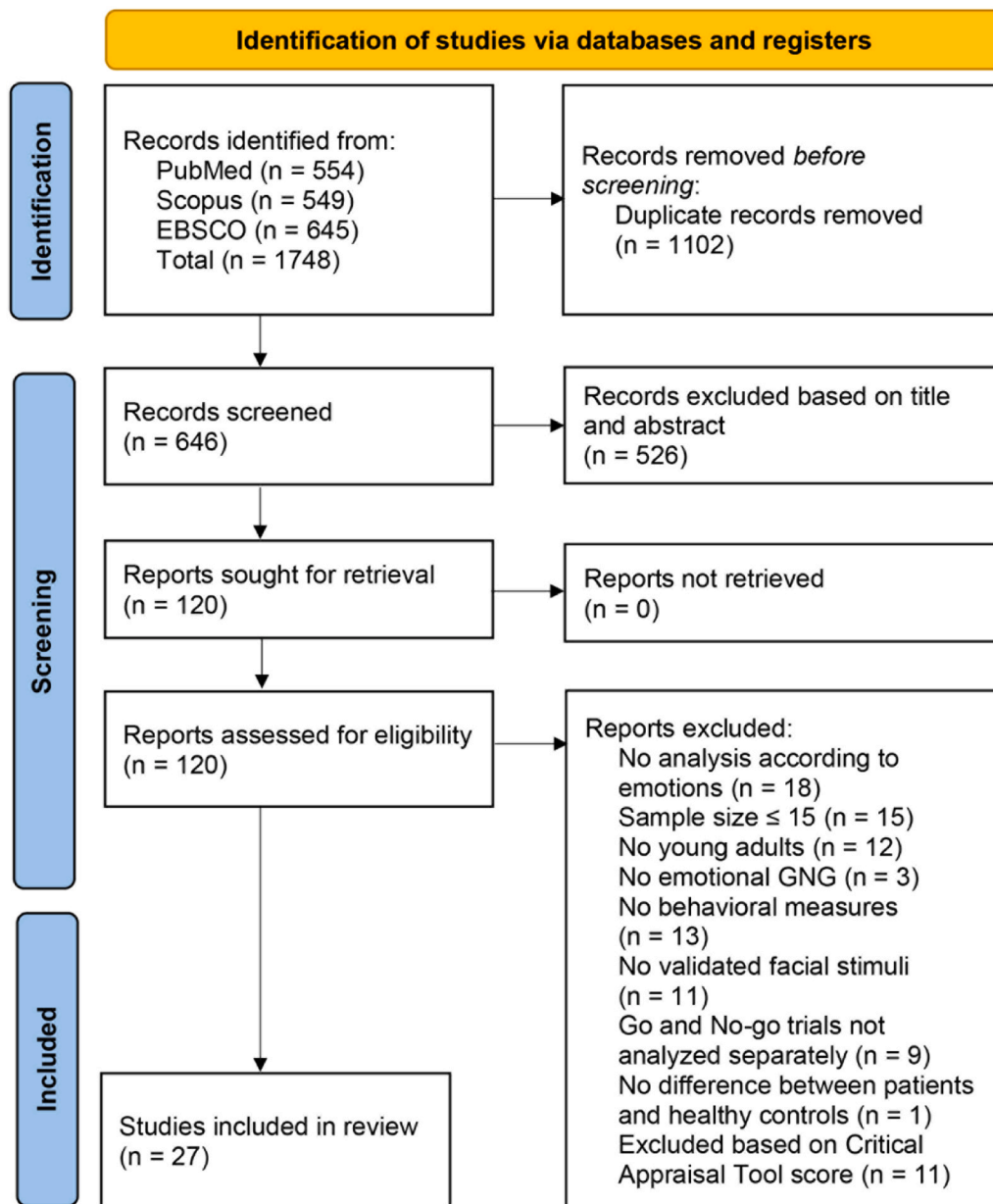


Fig. 2. Flowchart of the literature search and study selection process for Go/No-Go task studies conducted on March 19, 2025. The search was limited to English-language publications containing the keywords: *emoti** AND (*face** OR *facial*) AND (*"go no go"* OR *"go nogo"* OR *"gonogo"*) in the title or abstract, with no restrictions on publication date. After the initial screening of titles and abstracts, full-text articles were assessed against predefined eligibility criteria (see [Section 2.3](#)). Thirty-eight articles met the inclusion criteria.

classified within the go-signal category. With respect to goal-relevance, the majority of studies ($n = 11$) treated emotional valence as goal-irrelevant. Only three studies required explicit emotion categorization, rendering valence goal-relevant. Two studies included both relevant and irrelevant conditions within the same experimental design (one using a within-subject design, [Liang et al., 2022](#); and one a between-subjects design, [Williams et al., 2020](#)), allowing direct comparisons of goal-relevance effects within a single study.

3.2.2. Methodological features of selected Go/No-Go task studies

As shown in [Table 4](#), the use of emotional faces within GNG paradigms was more heterogeneous than in SST studies. Most frequently, emotional expressions served as both go- and no-go signals ($n = 14$), typically within variants of Hare's design ([Hare et al., 2005](#)), in which participants were instructed to respond to one emotional category and inhibit responses to others, with response-emotion mappings reversed

across blocks. In six additional studies employing within-subject designs, emotional faces served exclusively as go- or no-go signals in an emotion-evaluation condition, and were contrasted with a gender-evaluation condition in which faces functioned as both go- and no-go signals. One study used emotional expressions exclusively as no-go signals. In five studies, emotional faces did not directly define response contingencies but were instead presented as distractors, background stimuli, or primes.

With respect to goal-relevance, emotional valence was exclusively goal-relevant in 13 GNG studies, requiring explicit categorization of facial expressions to determine whether responses were executed or inhibited. In most of these cases, the task structure followed a blocked design, with the relevant emotional category alternating across blocks. In seven studies, emotional valence was exclusively goal-irrelevant, either because faces were task-irrelevant (e.g., distractors, primes, or background stimuli) or because responses were based on non-emotional

Table 1

Quality assessment of Stop-Signal Task studies.

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Total	Outcome
Pessoa et al. (2012)	2	0.5	2	N/A	N/A	N/A	0.5	1	60	Included
Pawliczek et al. (2013)	2	1.5	1	N/A	N/A	N/A	0.5	1	60	Included
Rebetez et al. (2015)	2	0.5	2	N/A	N/A	N/A	0	1	55	Included
Song et al. (2016)	2	1.5	2	N/A	N/A	N/A	0	1	65	Included
Ding et al. (2020)	2	1.5	2	N/A	N/A	N/A	0	2	75	Included
Williams et al. (2020)	2	2	2	N/A	N/A	N/A	0	1.5	75	Included
Gupta and Singh (2021)	2	1	1.5	N/A	N/A	N/A	0	1	55	Included
Battaglia et al. (2022)	2	2	2	N/A	N/A	N/A	1	1	80	Included
Liang et al. (2022)	2	2	1.5	N/A	N/A	N/A	0	0	55	Included
Pandey and Gupta (2022a)	2	1	2	N/A	N/A	N/A	0	2	70	Included
Pandey and Gupta (2022b)	2	1	1	N/A	N/A	N/A	0	1.5	55	Included
Gupta and Singh (2023)	2	1	2	N/A	N/A	N/A	0	1	60	Included
Jia et al. (2023)	2	2	2	N/A	N/A	N/A	0	1	70	Included
Lodha and Gupta (2024)	2	1	1.5	N/A	N/A	N/A	0	2	65	Included
Pandey and Gupta (2025)	2	0.5	1.5	N/A	N/A	N/A	1	0.5	65	Included
Cohen's k	1	0.73	0.63	1	1	1	0.76	0.88		

Note. Each study was evaluated using the Joanna Briggs Institute (JBI) critical appraisal checklist. Q1–Q8 correspond to the individual JBI appraisal questions. The original JBI response format (e.g., yes/no/unclear) was converted into a numerical scoring system for quantitative comparison (see Section 2.3). Items were scored from 0 to 2 in 0.5-point increments or coded as not applicable (N/A). Total scores represent the sum of applicable items (expressed as percentages of the maximum possible score). Cohen's k (unweighted) indicated the inter-rater agreement for each question. Studies are presented in chronological order by publication year.

Table 2

Quality assessment of Go/No-Go studies.

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Total	Outcome
Maxwell et al. (2005)	2	0.5	1.5	N/A	N/A	N/A	1	0.5	55	Included
Tamietto et al. (2006)	2	1.5	0	N/A	N/A	N/A	1	1	55	Included
Schulz et al. (2007)	2	1.5	0.5	N/A	N/A	N/A	1	1	60	Included
Windmann and Chmielewski (2008)	1	1	1	N/A	N/A	N/A	1	0	40	Excluded
Schulz et al. (2009)	2	1.5	0.5	N/A	N/A	N/A	1	1	60	Included
Putman et al. (2010)	1	0.5	1	N/A	N/A	N/A	1	2	55	Included
Vanderhasselt et al. (2011)	2	0.5	1	N/A	N/A	N/A	2	0.5	60	Included
Euser and Franken (2012)	2	1.5	0.5	N/A	N/A	N/A	1	0	50	Excluded
Pacheco-Unguetti et al. (2012)	1	0.5	2	2	1	1	1	0.5	56.25	Included
Zhang and Lu (2012)	2	0.5	0.5	N/A	N/A	N/A	2	1	60	Included
Carvalho Fernando et al. (2013)	2	1.5	0.5	N/A	N/A	N/A	1	1	60	Included
Cecere et al. (2013)	1	0.5	0.5	N/A	N/A	N/A	1	0	30	Excluded
Ma et al. (2013)	2	1.5	0	N/A	N/A	N/A	1	1.5	60	Included
Roberts et al. (2013)	2	0.5	0.5	N/A	N/A	N/A	1	0	40	Excluded
Schlosser et al. (2013)	2	2	0	N/A	N/A	N/A	1	1	60	Included
Schel and Crone (2013)	2	1.5	0.5	N/A	N/A	N/A	1	0	50	Excluded
Ly et al. (2014)	2	0.5	1	N/A	N/A	N/A	1	0	45	Excluded
Yang et al. (2014)	2	1	0	N/A	N/A	N/A	2	0	50	Excluded
Pornpattananangkul et al. (2015)	2	0.5	2	N/A	N/A	N/A	1	2	75	Included
Zhang et al. (2016)	2	0.5	0.5	2	1	1	2	0	56.25	Included
da Cunha-Bang et al. (2017)	2	1.5	0.5	N/A	N/A	N/A	1	0	50	Excluded
Gutierrez-Cobo et al. (2017)	2	1.5	1	N/A	N/A	N/A	1	0	55	Included
Parkinson et al. (2017)	1	0.5	1.5	N/A	N/A	N/A	1	1.5	55	Included
Sinke et al. (2017)	2	0.5	1.5	N/A	N/A	N/A	1	0.5	55	Included
Soloff et al. (2017)	2	0.5	0	N/A	N/A	N/A	1	0	35	Excluded
Yu et al. (2017)	2	0.5	2	N/A	N/A	N/A	2	1	75	Included
Mirabella (2018)	2	0.5	2	N/A	N/A	N/A	2	2	85	Included
Taylor et al. (2018)	2	0.5	0	N/A	N/A	N/A	1	0	35	Excluded
Quaglia et al. (2019)	2	1	0.5	N/A	N/A	N/A	1	1	55	Included
Waring et al. (2019)	2	2	1	N/A	N/A	N/A	1	1.5	75	Included
Mancini et al. (2020)	2	0.5	2	N/A	N/A	N/A	2	2	85	Included
Zhang et al. (2020)	2	1	1.5	N/A	N/A	N/A	2	0	65	Included
Vandewouw et al. (2021)	2	0.5	0	N/A	N/A	N/A	1	1	45	Excluded
Mancini et al. (2022)	2	1	2	N/A	N/A	N/A	2	2	90	Included
Montalti and Mirabella (2023)	2	1	2	N/A	N/A	N/A	2	2	90	Included
Mirabella et al. (2024b)	2	1	2	N/A	N/A	N/A	2	2	90	Included
Montalti and Mirabella (2024)	2	1	2	N/A	N/A	N/A	2	2	90	Included
Yeung et al. (2024)	2	2	0.5	N/A	N/A	N/A	1	1	65	Included
Cohen's k	0.80	0.94	1	1	1	1	0.94	0.88		

Note. Each study was evaluated using the Joanna Briggs Institute (JBI) critical appraisal checklist. Q1–Q8 correspond to the individual JBI appraisal questions. The original JBI response format (e.g., yes/no/unclear) was converted into a numerical scoring system for quantitative comparison (see Section 2.3). Items were scored from 0 to 2 in 0.5-point increments or coded as not applicable (N/A). Total scores represent the sum of applicable items (expressed as percentages of the maximum possible score). Cohen's kappa (unweighted) indicated the inter-rater agreement for each question. Studies are presented in chronological order by publication year.

features such as gender. Finally, seven studies included both goal-relevant and goal-irrelevant conditions within the same experimental

design, thereby allowing direct within-study comparisons of goal-relevance effects.

Table 3
Summary of Stop-Signal Task studies' features.

Study	Number of participants (M/F)	Mean Age $\pm$ SD [range] years	Task's features	Goal-relevance of emotional stimuli (and their role in the task)	Number of Trials	Stop-signal frequency	Face Emotions (Database)	Arousal Assessment
Pessoa et al., (2012)	32 (15/17)	[18–27]	Go-signal: Circle/Square Stop-signal: Brief picture of a face shown inside the shape stimulus	Irrelevant (stop-signal)	900	20%	Fearful, happy, neutral (KDEF; PoFA; Ishai-NIMH set; NimStim)	N/A
Pawliczek et al., (2013)	LA: 16 (16/0)	LA: 22.4 $\pm$ 2.3	Go-signal: Facial pictures surrounded by a white frame Stop-signal: Colour frame turning yellow	Irrelevant (go-signal)	400	25%	Angry, neutral (FEBA)	N/A
Rebetez et al., (2015)	84 (30/55)	22.8 $\pm$ 2.4 [18–30]	Go-signal: Gender categorization Stop-signal: Auditory signal	Irrelevant (go-signal)	384	25%	Angry, happy, neutral (KDEF)	N/A
Song et al., (2016)	83(36/47)	21.4 $\pm$ 2.2 [18–25]	Go-signal: Emotion categorization Stop-signal: Red cross over the face	Relevant (go-signal)	480	25%	Sad, neutral (CAPS)	Sad > Neutral [t(78) = 4.95, $p < 0.001$]
Ding et al., (2020)	20 (0/20)	21.2 $\pm$ 1.7	Go-signal: Emotion categorization Stop-signal: Red cross over the face	Relevant (go-signal)	480	25%	Sad, neutral (CAFPS)	Sad > Neutral [t(78) = 6.04, $p < 0.001$]
Williams et al., (2020)*	Exp. 1, YA: 40 (17/23)	Exp. 1, YA: 19.1 $\pm$ 1.7 [17–27]	Exp. 1 Go-signal: Circle/Square Stop-signal: Presentation of a face	Exp. 1: Irrelevant (stop-signal)	900	20%	Fearful, happy, neutral (KDEF; PoFA; Ishai-NIMH set; NimStim)	N/A
	Exp. 2, YA: 40 (18/22)	Exp. 2, YA: 18.7 $\pm$ 0.8 [17–20]	Exp. 2 Go-signal: Circle/Square/Face Stop-signal: Gender categorization	Exp. 2: Irrelevant (stop-signal)				
	Exp. 3, YA: 37 (15/22)	Exp. 3, YA: 19.2 $\pm$ 1.5 [18–26]	Exp. 3 Go-signal: Circle/Square/Face Stop-signal: Emotion categorization	Exp. 3: Relevant (stop-signal)				
Gupta and Singh, (2021)	45 (33/12)	26 $\pm$ 5.4	Go-signal: O/X Letter Stop-signal: Presentation of a face	Irrelevant (stop-signal)	192	25%	Angry, happy, neutral (KDEF and NimStim)	Angry > Neutral [t(1,30) = 4.19, $p < .0001$] Happy > Neutral [t(1,30) = 4.38, $p < .0001$] Angry = Happy [t(1,30) = 1.57, $p = .126$] Fearful > Neutral [6.42 $\pm$ 2.56 vs. 3.53 $\pm$ 2.03, $p < 0.001$]
Battaglia et al., (2022)	30 (14/16)	22.6 $\pm$ 3.7	Go-signal: Left/Right arrows Stop-signal: Presentation of a face	Irrelevant (stop-signal)	512	25%	Fearful, neutral (PoFA)	N/A
Liang et al., (2022)*	39 (15/24)	19.95 $\pm$ 1.3	Go-signal: Emotion categorization Stop-signal: Stop symbol Go-signal: Gender categorization Stop-signal: Stop symbol	Relevant (go-signal) Irrelevant (go-signal)	240 (each task)	25%	Sad, neutral (CAPS)	
Pandey and Gupta, (2022) (a)	54 (29/25)	21.5 $\pm$ 3.9 [18–34]	Go-signal: Gender discrimination Stop-signal: Face appearing at the top of the go-signal	Irrelevant (go- and stop-signal)	1080	30%	Angry, happy, neutral (NimStim)	N/A
Pandey and Gupta, (2022) (b)	28 (25/3)	23.2 $\pm$ 4 [18–30]	Condition: Low attentional load Go-signal: Visual search with 2 letters Stop-signal: Presentation of a face	Irrelevant (stop-signal)	640	30%	Angry, happy, neutral (NimStim)	N/A
Gupta and Singh, (2023)	41 (15/26)	27.4 $\pm$ 3.8	Go-signal: O/X Letter Stop-signal: Presentation of a face	Irrelevant (stop-signal)	256	25%	Angry, fearful, happy, neutral (KDEF and NimStim)	Fearful < Angry [t(1,30) = 6.46, $p < .0001$] Fearful < Happy [t(1,30) = 4.38, $p < .0001$] Fearful = Neutral [t(1,30) = 1.44, $p = 0.160$] Neutral < Angry [t(1,30) = 4.19, $p < .0001$] Neutral < Happy [t(1,30) = 3.02, $p < 0.005$] Angry = Happy [t(1,30) = 1.57, $p = 0.126$]

(continued on next page)

Table 3 (continued)

Study	Number of participants (M/F)	Mean Age $\pm$ SD [range] years	Task's features	Goal-relevance of emotional stimuli (and their role in the task)	Number of Trials	Stop-signal frequency	Face Emotions (Database)	Arousal Assessment
Jia et al., (2023)	LS: 24 (12/12)	LS: 22.3 $\pm$ 2.7	Go-signal: Emotion categorization Stop-signal: Colour frame turning red	Relevant (go-signal)	480	25%	Angry, neutral (KDEF)	N/A
Lodha and Gupta, (2024)	NM: 34 (17/17)	NM: 25.9 $\pm$ 5	Go-signal: O/X letter Stop-signal: Green circle above the letter	Irrelevant (prime)	192	25%	Angry, happy, neutral (KDEF and NimStim)	Angry = Happy [$t(1,30) = 1.57, p = 0.126$] Neutral < Happy [$t(1,30) = 4.38, p < .0001$] Neutral < Angry [$t(1,30) = 4.19, p < .0001$]
Pandey and Gupta, (2025)*	Exp. 1: 30 (20/10)	Exp. 1: 19.9 $\pm$ 2 [18–27]	Exp.1 Go-signal: Transparent blue compound hierarchical letter stimuli Stop-signal: Presentation of a face in the background of the compound letter stimuli	Irrelevant (stop-signal)	Exp. 1: 800	30%	Exp. 1: Angry, happy, neutral (NimStim)	N/A
	Exp. 2: 30 (15/15)	Exp. 2: 19.5 $\pm$ 2.7 [18–27]	Exp.2 Go-signal: Hierarchical transparent blue compound-digit stimuli Stop-signal: Presentation of a face in the background of the compound letter stimuli		Exp. 2: 468		Exp. 2: Angry, happy (NimStim, KDEF, Warsaw set, CFD)	N/A

Note. The table summarizes sample characteristics, task structure, goal-relevance of emotional stimuli (and their functional role within the task), and stimulus features of Stop-Signal studies. An asterisk (*) denotes studies including multiple experimental conditions: Williams et al. (2020) employed a between-subjects design comparing the effects of facial expressions when they were goal-relevant vs. goal-irrelevant; Liang et al. (2022) used a within-subject design contrasting goal-relevant and goal-irrelevant conditions; Pandey and Gupta (2025) conducted two experiments with different samples, varying the go-signal (letter vs. digits), while maintaining facial expressions as stop-signals. When a specific subgroup from a study was included, it is indicated in the second column (e.g., LA = Low Trait Aggression; LS = Low Schizotypy; YA = Younger Adults; NM = Non-Meditator group; NW-CG = Normal Weight-Control Group). Studies are listed in chronological order of publication. Abbreviations: CAFPS = Chinese Affective Face Picture System (Luo et al., 2010); CAPS = Chinese Affective Picture System (Lu et al., 2005); CFD = Chicago Face Database (Ma et al., 2015); FEBA = Facial Emotions for Brain Activation (Gur et al., 2002a); Ishai-NIMH set = Ishai – National Institute of Mental Health set (Ishai et al., 2004); KDEF, Karolinska Directed Emotional Faces (Lundqvist et al., 1998); PoFA = Pictures of Facial Affect (Ekman and Friesen, 1976); NimStim = The NimStim Set of Facial Expressions (Tottenham et al., 2009); Warsaw set = Warsaw set of emotional facial expression pictures (Olszanowski et al., 2014); Exp. = Experiment; F = Female; M = Male; N/A = Not Available; SD = Standard Deviation.

Taken together, these patterns reveal a systematic divergence between SST and GNG paradigms in how emotional valence is embedded within inhibitory control tasks. In SST studies, emotional information is predominantly incidental to task goals, with facial expressions more often serving as perceptual features that accompany response execution or inhibition without defining it. In contrast, GNG paradigms more frequently position emotional valence as a task-defining feature, requiring explicit categorization to determine response contingencies. At the same time, both paradigms exhibit considerable methodological variability, particularly in the implementation of goal-relevance manipulations and stimulus–response mappings, which may complicate direct comparisons across studies and paradigms.

3.3. Meta-analytic results for the Stop-Signal Task

Table 5 summarizes the meta-analytic estimates for the SST studies following sensitivity analyses. We performed pooled SSRT analyses comparing: (a) neutral and negatively valenced faces; (b) neutral and positively valenced faces; and (c) positively and negatively valenced faces.

3.3.1. Comparison of stop-signal reaction times for neutral vs. negative facial expressions

The final pooled analysis (Table 5 and Fig. 3), conducted after exclusion of Pessoa et al. (2012), which was identified as an influential study according to the predefined leave-one-out sensitivity analyses (see Section 2.8, Table 6 and S3 in the Supplemental Materials), indicated that negative valence significantly affected inhibitory control when

stimuli were goal-relevant, with negative facial expressions associated with longer SSRT compared to neutral expressions. In contrast, no significant effect emerged when emotional stimuli were goal-irrelevant. The test of moderators confirmed that goal-relevance significantly moderated the association between emotional valence and inhibitory control. Between-study heterogeneity was negligible in the goal-relevant subgroup but remained substantial in the goal-irrelevant subgroup, indicating greater variability in effects when emotional information was not directly relevant to participants' goals.

Liang et al. (2022), the only study directly comparing goal-relevant and goal-irrelevant conditions within subjects, was not included in the meta-analysis. Its findings were nevertheless consistent with the present results, showing longer SSRT for negative relative to neutral faces only when emotional information was goal-relevant.

3.3.2. Comparison of stop-signal reaction times for neutral vs. positive facial expressions

The comparison of SSRT for neutral and positive facial expressions was restricted to the goal-irrelevant subgroup, as Williams et al. (2020; Exp. 3) was the only study providing data for this contrast under goal-relevant conditions. Consequently, a quantitative meta-analysis of the goal-relevant subgroup was not feasible. The final pooled analysis (Table 5 and Fig. 4), conducted after excluding Pessoa et al. (2012) as influential (see Tables 6 and S5), indicated that emotional valence did not significantly affect inhibitory control when comparing neutral and positive facial expressions in the goal-irrelevant condition.

Although Williams et al. (2020; Exp. 3), was not included in the meta-analysis, it similarly indicated no significant difference in SSRT

Table 4
Summary of Go/No-Go task studies' features.

Study	Participants Total (M/F)	Mean Age $\pm$ SD [range] years	Task's features	Goal-relevance of emotional stimuli (and their role in the task)	Number of Trials	No-go signal frequency	Face Emotions (Database)	Arousal Assessment
Maxwell et al., (2005)	43 (21/22)	[18–30]	Lateralized shape categorization (faces centrally displayed as distractors)	Irrelevant (distractor)	168	29%	Angry, happy, neutral (PoFA)	N/A
Tamietto et al., (2006)*	Exp. 2: 25 (5/20)	Exp. 2: 25.3 $\pm$ 3.6 [19–32]	Hare's Design	Relevant (go- and no-go signal)	1536	33%	Fearful, happy, neutral (PoFA)	N/A
	Exp. 3: 20 (5/15)	Exp. 3: 24.6 $\pm$ 3.8 [22–28]			768		Fearful, happy (PoFA)	
Schulz et al., (2007)	85 (23/62)	26.1 $\pm$ 10.8 [18–66]	Hare's Design	Relevant (go- and no-go signal)	384	25%	Happy, sad (NimStim)	N/A
Schulz et al., (2009)	24 (16/8)	[18–35]	Hare's Design	Relevant (go- and no-go signal)	576	25%	Happy, sad, neutral (NimStim)	N/A
Putman et al., (2010)	28 (0/28)	22.7 $\pm$ 2.6 [19–28]	Hare's Design	Relevant (go- and no-go signal)	384	25%	Fearful, happy (KDEF)	N/A
Vanderhasselt et al., (2011)	34 (9/25)	21.6 $\pm$ 2.4	Hare's Design	Relevant (go- and no-go signal)	800	20%	Happy, sad (KDEF)	Happy = Sad [Fs < 1.13, p > 0.18]
Pacheco-Unguetti et al., (2012)	Exp. 1: 58 (21/37)	Exp. 1: 25.6 $\pm$ 7.5	<i>Low attentional load condition</i> : Letter discrimination (printed over faces' image)	Irrelevant (background)	360	33%	Angry, happy, neutral (KDEF, FACS, NimStim)	N/A
Zhang and Lu, (2012)	20 (11/9)	[18–20]	Go-signal: face gender consistent with the preceding word cue. No-go signal: Face gender and word cue not matching	Irrelevant (go- and no-go signal)	324	50%	Angry, Fearful, happy, neutral (CFAPS)	Positive = Neutral = Angry = Fearful [F (2159) = 1.86, p > 0.05]
Carvalho Fernando et al., (2013)	CON: 32 (0/32)	CON: 29.5 $\pm$ 9.1	Hare's Design	Relevant (go- and no-go signal)	216	33%	Fearful, happy, neutral (NimStim)	N/A
Ma et al., (2013)	30 (8/22)	21.4 $\pm$ 2.7 [18–28]	Hare's Design	Relevant (go- and no-go signal)	240	50%	Happy, sad, neutral (CFAPS)	Sad > Happy > Neutral [F(2,57) = 222.2, p < 0.001]
Schlosser et al., (2013)	54 (19/35)	31.5 $\pm$ 10.3	Hare's Design	Relevant (go- and no-go signal)	216	33%	Fearful, happy, neutral (NimStim)	N/A
Pornpattananangkul et al., (2015)	36 (15/21)	18.56 $\pm$ NA	Go-signal: neutral faces No-go signal: emotional faces	Relevant (no-go signal)	640	25%	Fearful, happy, neutral (NimStim)	N/A
Zhang et al., (2016)	Neutral priming: 29 (14/15)	Neutral priming: 21.5 $\pm$ 2.2 [18–26]	Hare's Design (before the task participants saw a neutral video)	Relevant (go- and no-go signal)	400	30%	Angry, happy (CFAPS)	Happy = Angry [t (19) = 0.965, p > 0.05]
Gutierrez-Cobo et al., (2017)	187 (49/138)	21.9 $\pm$ 3.82 [19–48]	Hare's Design	Relevant (go- and no-go signal)	240	30%	Angry, fearful, happy, sad, neutral (PoFA)	N/A
Parkinson et al., (2017)	Exp. 3: 16 (6/10)	Exp 3: 19.7 $\pm$ 1.6	Go-signal: Green circle (reactive go)/ Yellow circle (intentional choice) No-go signal: red circle	Irrelevant (prime)	720	16%	Angry, neutral (NimStim)	N/A
Sinke et al., (2017)	16 (1/15)	28.9 $\pm$ 8.3	Shape discrimination (printed over faces' image)	Irrelevant (background)	450	30%	Angry, happy, neutral (NimStim)	N/A
Yu et al., (2017)*	CON: 21 (0/21)	CON: 25.9 $\pm$ 6.2	Hare's Design	Relevant (go- and no-go signal)	480 (each task)	30%	Sad, neutral (CFAPS)	Sad = Neutral [p > 0.05]
			Gender categorization	Irrelevant (go- and no-go signal)				
Mirabella, (2018)*	40 (20/20)	24.9 $\pm$ 2.9	Go-signal: emotional faces No-go signal: neutral faces	Relevant (go-signal)	360 (each task)	33%	Fearful, happy, neutral (PoFA)	Fearful > Neutral [4.26 $\pm$ 1.3 vs. 1.89 $\pm$ 1.6, (continued on next page)]

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Table 4 (continued)

Study	Participants Total (M/F)	Mean Age $\pm$ SD [range] years	Task's features	Goal-relevance of emotional stimuli (and their role in the task)	Number of Trials	No-go signal frequency	Face Emotions (Database)	Arousal Assessment
			Gender categorization	Irrelevant (go- and no-go signal)				$p < .0001$] Happy $>$ Neutral [4.49 $\pm$ 1.4 vs. 1.89 $\pm$ 1.6, $p < .0001$] Fearful = Happy [4.26 $\pm$ 1.3 vs. 4.49 $\pm$ 1.4, $p = 0.56$] N/A
Quaglia et al., (2019)	60 (19/41)	30.6 $\pm$ 9.1 [20–59]	Hare's Design	Relevant (go- and no-go signal)	960	30%	Fearful, happy, neutral (NimStim)	N/A
Waring et al., (2019)	YA: 44 (24/20)	YA: 19 $\pm$ 1.14 [18–22]	Hare's Design	Relevant (go- and no-go signal)	288	27%	Fearful, happy, neutral (NimStim)	N/A
Mancini et al., (2020) *	56 (28/28)	22.4 $\pm$ 2.4	Go-signal: emotional faces No-go signal: neutral faces Gender categorization	Relevant (go-signal) Irrelevant (go- and no-go signal)	396 (each task)	33%	Angry, fearful, happy, neutral (PoFA)	Angry $<$ Happy [t(55) = 8.28, $p < .0001$] Angry $<$ Fearful [t(55) = 8.81, $p < .0001$] Happy = Fear [t(55) = 2.48, $p = 0.049$] Angry = Happy [t(39) = 0.965, $p > 0.05$]
Zhang et al., (2020)	CON: 28 (5/23)	CON: 24.3 $\pm$ 4.9 [17–39]	Gender categorization (emotional or neutral verb presented as a priming word)	Irrelevant (go- e no-go signal)	520	30%	Angry, happy (CFAPS)	
Mancini et al., (2022) *	40 (20/20)	23.9 $\pm$ 4.7	Go-signal: emotional faces No-go signal: neutral faces Gender categorization	Relevant (no-go signal) Irrelevant (go- and no-go signal)	500 or 600	33%	Fearful, happy, neutral (PoFA)	Fearful $>$ Neutral [5.04 $\pm$ 1.37 vs. 1.00 $\pm$ 1.04, $p < 0.001$] Happy $>$ Neutral [4.91 $\pm$ 1.61 vs. 1.00 $\pm$ 1.04, $p < 0.001$] Fearful = Happy [5.04 $\pm$ 1.37 vs. 4.91 $\pm$ 1.61, $p = 1.00$] Fearful $>$ Neutral [4.66 $\pm$ 1.1 vs. 2.03 $\pm$ 1.02, $p < .0001$] Happy $>$ Neutral [4.08 $\pm$ 0.95 vs. 2.03 $\pm$ 1.02, $p < .0001$] Fearful $>$ Happy [4.66 $\pm$ 1.1 vs. 4.08 $\pm$ 0.95, $p = 0.001$] Fearful $>$ Neutral [5.07 $\pm$ 1.49 vs. 1.43 $\pm$ 1.49, $p < 0.001$] Happy $>$ Neutral [5.51 $\pm$ 1.26 vs. 1.43 $\pm$ 1.49, $p < 0.001$] Fearful = Happy [5.07 $\pm$ 1.49 vs. 5.51 $\pm$ 1.26, $p = 0.67$] Neutral $<$ Angry [2.12 $\pm$ 1.21 vs. 4.39 $\pm$ 1.48, $p < .0001$] Neutral $<$ Fearful [2.12 $\pm$ 1.21 vs. 4.49 $\pm$ 1.47, $p < .0001$] Neutral $<$ Happy [2.12 $\pm$ 1.21 vs. 3.69 $\pm$ 1.21, $p < .0001$]
Montalti and Mirabella, (2023)*	40 (20/20)	23.6 $\pm$ 4.1 [19.9–32.5]	Go-signal: emotional faces No-go signal: neutral faces Gender categorization	Relevant (go-signal) Irrelevant (go- and no-go signal)	576 (each task)	33%	Fearful, happy, neutral (KDEF)	
Mirabella et al., (2024b)*	23 (8/15)	23 $\pm$ 3.1 [19–31]	Go-signal: emotional faces No-go signal: neutral faces Gender categorization	Relevant (go-signal) Irrelevant (go- and no-go signal)	360	33%	Fearful, happy, neutral (PoFA)	
Montalti and Mirabella, (2024)*	40 (20/20)	24.5 $\pm$ 3.6 [19.7–32.9]	Go-signal: emotional faces No-go signal: neutral faces Gender categorization	Relevant (go-signal) Irrelevant (go- and no-go signal)	432 (each task)	33%	Angry, fearful, happy, neutral (KDEF)	

(continued on next page)

Table 4 (continued)

Study	Participants Total (M/F)	Mean Age $\pm$ SD [range] years	Task's features	Goal-relevance of emotional stimuli (and their role in the task)	Number of Trials	No-go signal frequency	Face Emotions (Database)	Arousal Assessment
								± 1.67 , $p < .0001$] Happy < Angry [3.69 ± 1.67 vs. 4.39 ± 1.48 , $p < .0001$] Happy < Fearful [3.69 ± 1.67 vs. 4.49 ± 1.47 , $p < .0001$] Angry = Fearful [4.39 ± 1.48 vs. 4.49 ± 1.47 , $p = 1.00$] N/A
Yeung et al., (2024)	45 (16/29)	20.7 $\pm$ 0.7	Non-incentive condition: Number categorization (printed over faces' image)	Irrelevant (background)	384	75%	Angry, fearful, neutral (TFED)	

Note. The table summarizes sample characteristics, task structure, goal-relevance of emotional stimuli (and their functional role within the task), and stimulus features of Go/No-Go studies. An asterisk (*) denotes studies including multiple experimental conditions: Tamietto et al. (2006) conducted two experiments with different samples and varying the number of trials and using positive, negative and neutral emotions in one case, and only positive and negative emotions in the other. Mancini et al. (2020), (2022); Mirabella (2018); Mirabella et al. (2024b); Montalti and Mirabella (2023), (2024); Yu et al. (2017) employed within-subject designs contrasting goal-relevant and goal-irrelevant conditions. When a specific subgroup from a study was included, it is indicated in the second column (e.g., CON = Control participants; YA = Younger Adults). Studies are listed in chronological order of publication. Abbreviations: CFAPS = Chinese Facial Affective Picture System (Gong et al., 2011; Wang and Luo, 2005); KDEF = Karolinska Directed Faces (Lundqvist et al., 1998); NimStim = The NimStim Set of Facial Expressions (Tottenham et al., 2009); PoFA = Pictures of Facial Affect (Ekman and Friesen, 1976); TEFD = Tsinghua Facial Expression Database (Yang et al., 2020); FACS = Facial Action Coding System (Ekman and Friesen, 1978); Exp. = Experiment; F = Female; M = Male; N/A = Not Available; SD = Standard Deviation.

Table 5

Meta-analytic estimates for the Stop-Signal Task.

Comparison	Number of studies	Hedges' g	95% CI	Z	p-value for Z	Prediction Interval	Q Statistic	p-value for Q	I ²	τ ²	Regression Test for Funnel Plot Asymmetry	Rank Correlation Test for Funnel Plot Asymmetry (Kendall's tau)
SSRT Neutral vs. Negative												
Overall	15						52.919	< .0001	73.544%	0.071	β = −4.919,	tau = −0.171
Task-relevant	4	0.370	[0.214, 0.526]	4.645	< .0001	[-]	2.643	0.450	0%	0	t = 2.574,	p = 0.187
Task-irrelevant	11	−0.003	[−0.193, 0.187]	−0.033	0.974	[−0.661, 0.655]	39.61	< .0001	74.752%	0.075	p = 0.012	
Irrelevant vs. Relevant	Test of Moderators (Q-between) = 8.821, p = 0.003											
SSRT Neutral vs. Positive												
Task-irrelevant	7	0.077	[−0.045, 0.199]	1.241	0.215	[−0.175, 0.329]	7.649	0.265	21.555%	0.006	β = −3.104, t = 1.147, p = 0.152	tau = 0.000, p = 0.500
SSRT Positive vs Negative												
Task-irrelevant	10	0.054	[−0.092, 0.201]	0.728	0.466	[−0.388, 0.497]	21.006	0.013	57.155%	0.031	β = −2.462, t = 0.798, p = 0.224	tau = −0.089, p = 0.360

Note. Reported values correspond to the final random-effects meta-analytic estimates of pooled stop-signal reaction time (SSRT) following sensitivity analyses and removal of identified influential outlier studies (see text for more details). Prediction intervals cannot be computed when between-study heterogeneity (I^2 , τ^2) equals zero, as variability among study-level effect sizes is required to estimate the expected range of effects in a new study. Bold values indicate statistically significant results.

between positive and neutral faces when emotional information was goal-relevant.

3.3.3. Comparison of stop-signal reaction times for positive vs. negative facial expressions

As only one study examined this contrast under goal-relevant conditions (Williams et al., 2020, Exp 3.), the meta-analysis for positive and

negative facial expressions was limited to the goal-irrelevant subgroup. The final pooled analysis (Table 5 and Fig. 5), conducted after excluding Pessoa et al. (2012) as influential (see Tables 6 and S6 in the Supplemental Materials), showed no significant difference in SSRT between positive and negative facial expressions. Although between-study heterogeneity was reduced following the sensitivity analysis, variability across studies remained moderate.

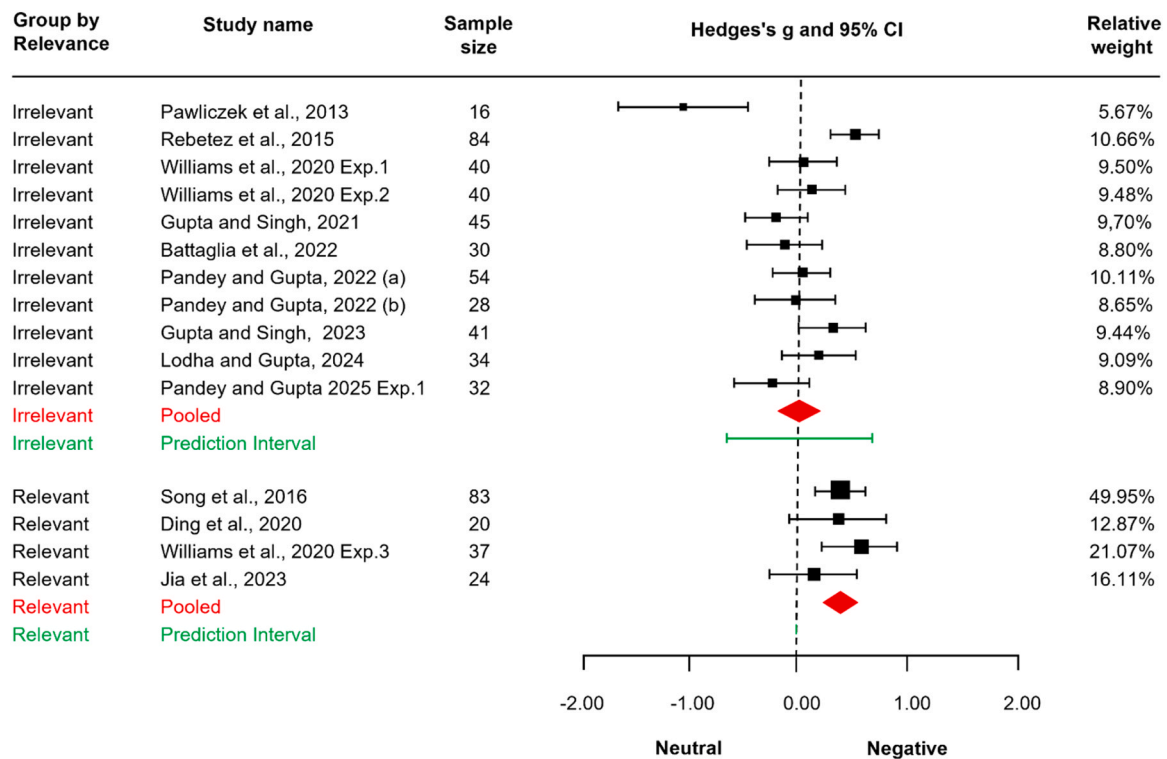


Fig. 3. Forest plot of random-effects meta-analysis comparing stop-signal reaction times (SSRT) for neutral versus negative facial expressions, stratified by goal-relevance. The plot depicts the Hedges' g and 95% confidence interval for each study. Diamonds represent the pooled Hedges' g with 95% confidence intervals; horizontal bars denote prediction intervals. Positive values indicate longer SSRT for negative relative to neutral faces, whereas negative values indicate longer SSRT for neutral relative to negative faces. The prediction interval cannot be calculated if between-study heterogeneity is zero.

Table 6

Sensitivity analyses of pooled SSRT effect sizes before and after exclusion of the influential study.

	Hedges' g	95% CI	p-value	I ²
SSRT Neutral vs. Negative – Goal-irrelevant subgroup				
Main analysis	-0.171	[-0.443, 0.102]	0.219	87.792%
Case removed (Pessoa et al., 2012)	-0.003	[-0.193, 0.187]	0.974	74.752%
SSRT Neutral vs. Positive – Goal-irrelevant subgroup				
Main analysis	-0.116	[-0.405, 0.173]	0.432	86.15%
Case removed (Pessoa et al., 2012)	0.077	[-0.045, 0.199]	0.215	21.55%
SSRT Positive vs Negative – Goal-irrelevant subgroup				
Main analysis	-0.016	[-0.200, 0.168]	0.865	74.38%
Case removed (Pessoa et al., 2012)	0.054	[-0.092, 0.201]	0.466	57.16%

Note. The "Main analysis" rows report pooled effect sizes including all studies. The "Case removed" rows report pooled effect sizes recalculated after exclusion of the identified influential study (Pessoa et al., 2012), as also reported in Table 5. Effect sizes are expressed as Hedges' g under a random-effects model. Abbreviations: SSRT = stop-signal reaction time; CI = confidence interval; I^2 = between-study heterogeneity.

In contrast to the present goal-irrelevant findings, Williams et al. (2020; Exp. 3) reported a different pattern under goal-relevant conditions, with significantly longer SSRTs for negative than for positive faces.

3.3.4. Publication bias in studies using the Stop-Signal Task

Across all emotional valence comparisons (neutral vs. negative, neutral vs. positive, and positive vs. negative facial expressions), pooling goal-relevant and goal-irrelevant studies, visual inspection of the funnel plots suggested symmetrical distributions of effect sizes (see Fig. 6). Consistent with this observation, neither Egger's regression test nor

Begg and Mazumdar's rank correlation test was statistically significant (see Table 5). These findings provide no evidence of small-study effects or publication bias.

3.4. Meta-analytic results: Go/No-Go studies

Table 7 summarizes the meta-analytic estimates for the GNG studies after sensitivity analyses. Separate random-effects meta-analytic models were estimated for each emotional valence contrast $\times$ outcome combination for RT, OE, and CE.

3.4.1. Comparison of reaction times for neutral vs. negative facial expressions

The final pooled analysis (Table 7 and Fig. 7), conducted after exclusion of Gutierrez-Cobo et al. (2017) in the goal-relevant subgroup, and Zhang and Lu (2012) in the goal-irrelevant subgroup as influential studies (see Tables 8, S7, and S8), indicated that negative emotional valence did not significantly affect RT in either condition. No significant differences between negative and neutral faces emerged when emotional stimuli were goal-relevant or goal-irrelevant. The test of moderators confirmed that goal-relevance did not significantly moderate the association between emotional valence and RT. Between-study heterogeneity was reduced following sensitivity analyses and was moderate in the goal-relevant subgroup but negligible in the goal-irrelevant subgroup (Table 7).

Yu et al. (2017), which directly compared goal-relevant and goal-irrelevant conditions within subjects, was not included in the meta-analysis. Its findings were nevertheless consistent with the present results, showing no significant differences in RT between negative and neutral faces in either condition.

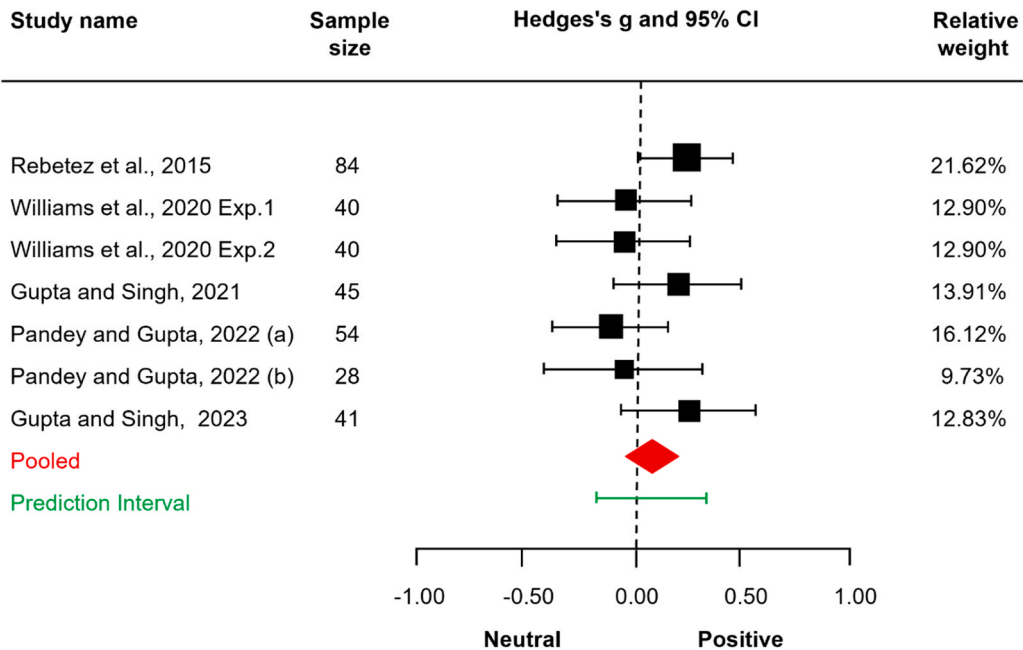


Fig. 4. Forest plot of random-effects meta-analysis comparing stop-signal reaction times (SSRT) for neutral versus positive facial expressions in the goal-irrelevant subgroup. Positive values indicate longer SSRT for positive relative to neutral faces, whereas negative values indicate longer SSRT for neutral relative to positive faces. All other conventions are as in Fig. 3.

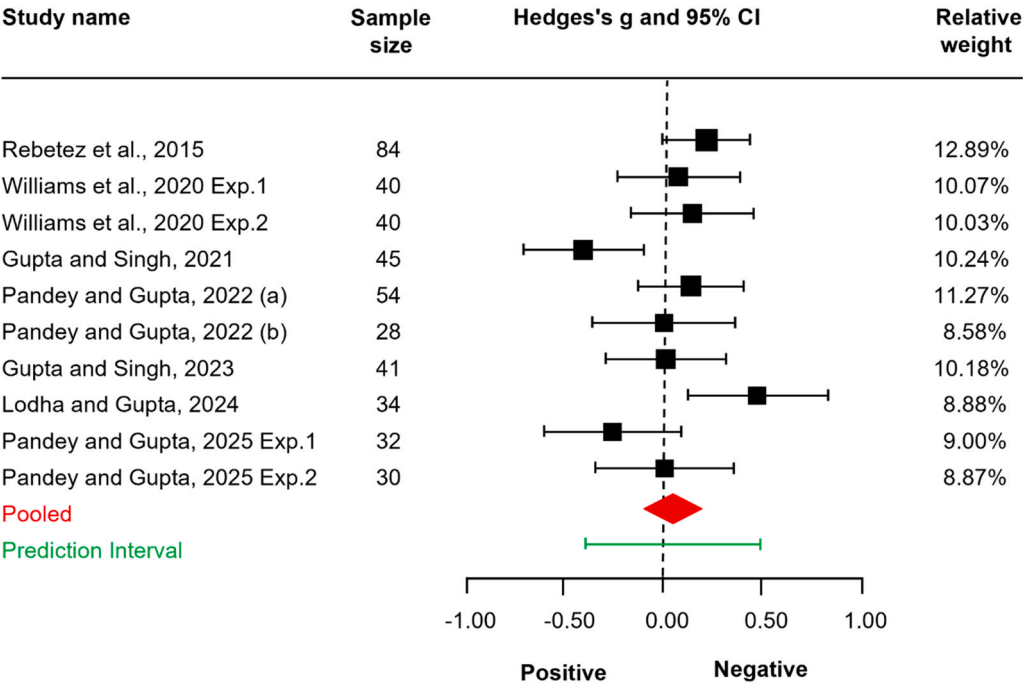


Fig. 5. Forest plot of random-effects meta-analysis comparing stop-signal reaction times (SSRT) for positive versus negative facial expressions in the goal-irrelevant subgroup. Positive values indicate longer SSRT for negative relative to positive faces; whereas negative values indicate longer SSRT for positive relative to negative faces. All other conventions are as in Fig. 3.

3.4.2. Comparison of reaction times for neutral vs. positive facial expressions

The comparison of RT for neutral and positive facial expressions was restricted to the goal-relevant subgroup, as only three studies included goal-irrelevant stimuli (Pacheco-Unguetti et al., 2012; Sinke et al., 2017; Zhang and Lu, 2012), precluding subgroup comparison. The final pooled analysis (Table 7 and Fig. 8), conducted after exclusion of Gutierrez-Cobo et al. (2017) as influential (see Tables 8 and S9),

indicated that positive emotional valence significantly affected RT when emotional stimuli were goal-relevant. Heterogeneity remained statistically significant, with moderate-to-substantial variability across studies (Table 7).

Among the three studies employing goal-irrelevant stimuli, two reported no significant RT differences (Pacheco-Unguetti et al., 2012; Sinke et al., 2017), whereas Zhang and Lu (2012) reported shorter RT for positive than for neutral stimuli.

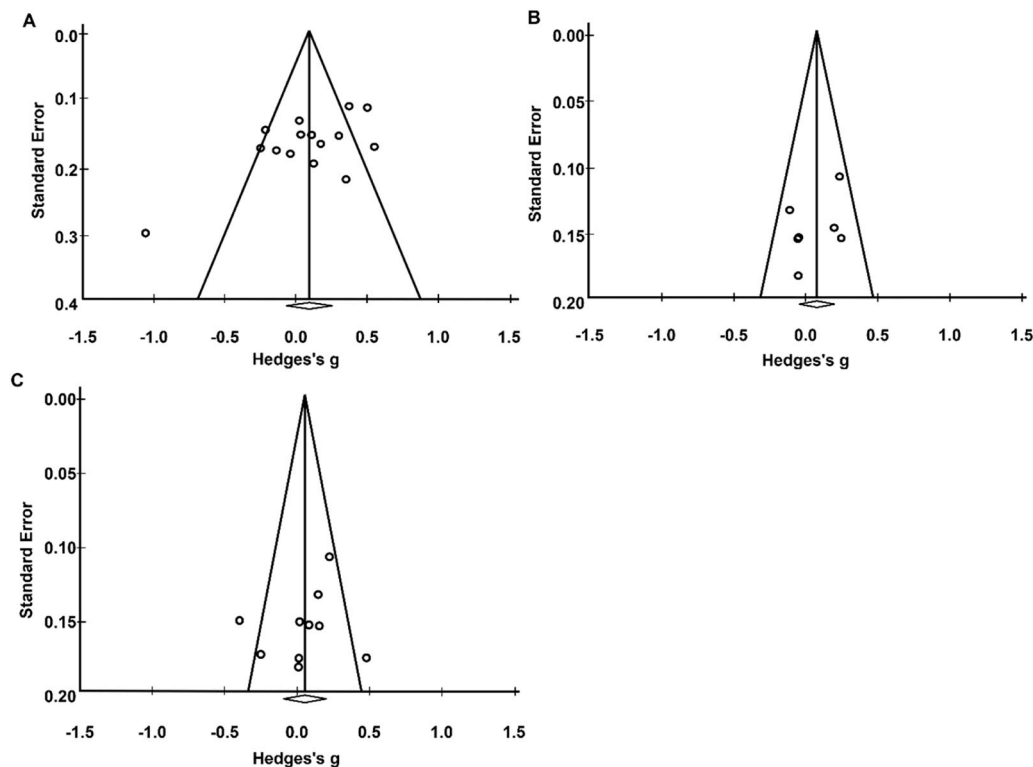


Fig. 6. Funnel plots for meta-analyses of SSRT differences between facial expressions. Panels depict (A) neutral vs. negative, (B) neutral vs. positive, and (C) positive vs. negative comparisons. The x-axis represents Hedges' g , and the y-axis represents the standard error. Each point corresponds to an individual study. The vertical line indicates the pooled effect estimated using a random-effects model, with the diamond representing its 95% confidence interval. Diagonal lines denote the expected distribution of studies in the absence of publication bias.

3.4.3. Comparison of reaction times for positive vs. negative facial expressions

The comparison of RT for positive and negative facial expressions was conducted separately for goal-relevant and goal-irrelevant subgroups. The final pooled analysis (Table 7 and Fig. 9), conducted after exclusion of Gutierrez-Cobo et al. (2017) in the goal-relevant subgroup and Zhang et al. (2020) in the goal-irrelevant subgroup as influential studies (see Tables 8, S10, and S11), indicated a significant effect of emotional valence in the goal-relevant condition, with longer RT for negative relative to positive faces. In contrast, no significant effect emerged in the goal-irrelevant subgroup. Heterogeneity was present in the goal-relevant subgroup but negligible in the goal-irrelevant subgroup (see Table 7). The test of moderators did not reach conventional statistical significance ($p = .058$; see Table 7), but it approached the .05 threshold.

3.4.4. Comparison of reaction times for positive vs. negative facial expressions in within-subject designs

This analysis was restricted to studies employing within-subject designs in which the same participants completed both goal-relevant and goal-irrelevant emotional conditions (Mancini et al., 2020; Mirabella, 2018; Mirabella et al., 2024b; Montalti and Mirabella, 2023, 2024). This design permits direct comparison of goal-relevant and goal-irrelevant conditions within the same participants, minimizing inter-individual variability.

Unlike the previous analyses, a three-level random-effects meta-analytic model was implemented to account for the dependence among effect sizes derived from the same samples. The pooled analysis (Table 7 and Fig. 10) indicated a statistically significant effect of emotional valence when emotional expressions were goal-relevant, with longer RT for negative relative to positive faces. No significant effect emerged in the goal-irrelevant condition. The test of moderators was

significant, indicating that the effect differed between goal-relevant and goal-irrelevant conditions. Heterogeneity was negligible, and the overall test of residual heterogeneity was not significant (see Table 7). Furthermore, all observed variability was attributable to within-study differences ($I^2_{\text{within}} = 4.45\%$), with no variability between studies ($I^2_{\text{between}} = 0\%$). Leave-one-out analyses did not identify influential studies.

3.4.5. Comparison of omission errors for neutral vs. negative and positive facial expressions

Meta-analyses examining OE for neutral versus negative and neutral versus positive facial expressions were not conducted due to the limited number of eligible studies, as OE data were rarely reported for these contrasts. For neutral versus negative comparisons, only three studies were available in the goal-relevant condition and two in the goal-irrelevant condition. Similarly, for neutral versus positive comparisons, three studies were identified in the goal-relevant condition and only one in the goal-irrelevant condition. Given these small numbers of studies per subgroup, separate meta-analyses would have lacked adequate statistical power and yielded unstable effect size estimates (Borenstein et al., 2009).

3.4.6. Comparison of omission errors for positive vs. negative facial expressions

The comparison of OE for positive and negative facial expressions was restricted to the goal-relevant subgroup, as only two studies included goal-irrelevant stimuli (Zhang et al., 2020; Zhang and Lu, 2012), precluding subgroup comparison. The final pooled analysis (Table 7 and Fig. 11), conducted after exclusion of Schulz et al. (2009) as influential (see Tables 9 and S14), indicated that emotional valence significantly affected OE when emotional stimuli were goal-relevant. Heterogeneity was low and not statistically significant following

Table 7

Meta-analytic estimates for the Go/No-Go task.

Comparison	Number of studies	Hedges' g	95% CI	Z	p-value for Z	Prediction Interval	Q Statistic	p-value for Q	I ²	τ ²	Regression Test for Funnel Plot Asymmetry	Rank Correlation Test for Funnel Plot Asymmetry (Kendall's tau)
RT Neutral vs. Negative												
Overall	9						12.063	0.148	33.679%	0.014	β = −1.665,	tau = −0.250,
Task-relevant	5	−0.105	[−0.322, 0.113]	−0.943	0.346	[−0.791, 0.581]	9.112	0.058	56.102%	0.034	t = 0.858, p = 0.209	p = 0.174
Task-irrelevant	4	0.079	[−0.086, 0.245]	0.940	0.347	[-]	1.076	0.783	0%	0		
Irrelevant vs. Relevant	Test of Moderators (Q-between) = 1.740, p = 0.187											
RT Neutral vs. Positive												
Task-relevant	5	−0.332	[−0.579, −0.085]	−2.636	0.008	[−1.148, 0.483]	11.059	0.026	63.830%	0.050	β = −5.354, t = 1.532, p = 0.111	tau = −0.500, p = 0.110
RT Positive vs. Negative												
Overall	13						25.527	0.013	52.990%	0.033	β = 2.820,	tau = 0.346,
Task-relevant	10	0.355	[0.185, 0.524]	4.098	< .0001	[−0.160, 0.870]	22.285	0.008	59.615%	0.042	t = 2.085, p = 0.031	p = 0.050
Task-irrelevant	3	0.103	[−0.095, 0.300]	1.020	0.308	[-]	0.228	0.892	0%	0		
Irrelevant vs. Relevant	Test of Moderators (Q-between) = 3.593, p = 0.058											
RT Positive vs. Negative in within-subject design												
Overall	5						7.681	0.465	4.450%	0	-	-
Task-relevant	5	0.481	[0.332, 0.630]	6.331	< .0001	[0.317, 0.645]	-	-	-	-		
Task-irrelevant	5	0.057	[−0.082, 0.197]	0.806	0.420	[−0.098, 0.213]	-	-	-	-		
Irrelevant vs. Relevant	Test of Moderators (Q-between) = 16.560, p < .0001											
OE Positive vs. Negative												
Task-relevant	4	0.197	[0.016, 0.378]	2.136	0.033	[−0.407, 0.802]	4.459	0.216	32.713%	0.011	β = 1.704, t = 0.566, p = 0.314	tau = 0.167, p = 0.367
OE Positive vs. Negative in within-subject design												
Overall							18.176	0.020	55.718%	0	-	-
Task-relevant	5	0.494	[0.275, 0.713]	4.419	< .0001	[0.075, 0.913]	-	-	-	-		
Task-irrelevant	5	0.058	[−0.154, 0.270]	0.539	0.590	[−0.357, 0.473]	-	-	-	-		
Irrelevant vs. Relevant	Test of Moderators (Q-between) = 7.861, p = 0.005											
CE Neutral vs. Negative												
Task-relevant	5	0.102	[−0.161, 0.364]	0.757	0.449	[−0.820, 1.024]	15.375	0.004	73.984%	0.066	β = −3.845, t = 0.468, p = 0.336	tau = −0.300, p = 0.231
CE Neutral vs. Positive												
Task-relevant	5	0.166	[−0.322, 0.654]	0.668	0.504	[−1.706, 2.038]	49.107	< .0001	91.855%	0.284	β = 4.252, t = 0.209, p = 0.424	tau = 0.000, p = 0.500
CE Positive vs. Negative												
Task-relevant	10	−0.073	[−0.254, 0.108]	−0.791	0.429	[−0.676, 0.530]	31.519	< .0001	71.445%	0.060	β = 5.590, t = 1.870, p = 0.049	tau = 0.311, p = 0.105

Note. RT, OE, and CE refer to reaction time, omission errors on go-trials, and commission errors on no-go trials, respectively, in the Go/No-Go task. Reported values correspond to the final random-effects meta-analytic estimates obtained after exclusion of influential outlier studies (see text for details). Prediction intervals cannot be computed when between-study heterogeneity (I^2 and τ^2) equals zero, as variability among study-level effect sizes is required to estimate the expected range of effects in a new study. Bold values indicate statistically significant results.

sensitivity analyses (see Table 7).

Among the two studies employing goal-irrelevant stimuli, Zhang and Lu (2012) reported no significant differences, whereas Zhang et al. (2020) found higher OE for negative relative to positive stimuli.

3.4.7. Comparison of omission errors for positive vs. negative facial expressions in within-subject designs

This analysis was restricted to studies employing within-subject designs in which the same participants completed both goal-relevant and goal-irrelevant emotional conditions (Mancini et al., 2020; Mirabella, 2018; Mirabella et al., 2024b; Montalti and Mirabella, 2023, 2024). A

three-level random-effects meta-analytic model was applied to account for the dependence among effect sizes derived from the same samples. The pooled analysis (Table 7 and Fig. 12) indicated a statistically significant effect of emotional valence when emotional expressions were goal-relevant, with a higher number of OE for negative relative to positive faces. No significant effect emerged in the goal-irrelevant condition. The test of moderators was significant, with a moderate difference between goal-relevant and goal-irrelevant conditions. Residual heterogeneity was attributable entirely to within-study variability, with no evidence of between-study heterogeneity ($I^2_{\text{between}} = 0\%$) and moderate within-study heterogeneity ($I^2_{\text{within}} = 55.72\%$). The overall test of

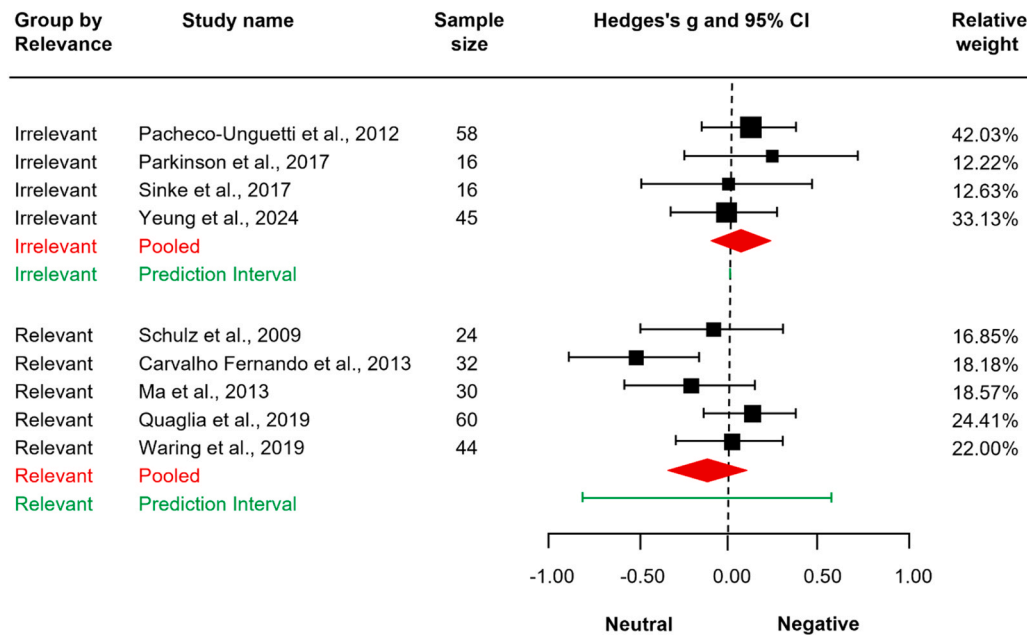


Fig. 7. Forest plot of random-effects meta-analysis comparing reaction times (RT) for neutral versus negative facial expressions, stratified by goal-relevance. Positive values indicate longer RT for negative relative to neutral faces; negative values indicate longer RT for neutral relative to negative faces; all other conventions are as in Fig. 3.

Table 8

Sensitivity analyses of pooled RT effect sizes before and after exclusion of the influential study.

	Hedges' g	95% CI	p-value	I ²
RT Neutral vs. Negative – Goal-relevant subgroup				
Main analysis	0.376	[-0.596, 1.349]	0.448	98.19%
Case removed (Gutierrez-Cobo et al., 2017)	-0.105	[-0.322, 0.113]	0.346	56.10%
RT Neutral vs. Negative – Goal-irrelevant subgroup				
Main analysis	-0.101	[-0.446, 0.244]	0.567	76.05%
Case removed (Zhang and Lu, 2012)	0.079	[-0.086, 0.245]	0.347	0%
RT Neutral vs. Positive – Goal-relevant subgroup				
Main analysis	-0.541	[-1.068, -0.014]	0.044	94.63%
Case removed (Gutierrez-Cobo et al., 2017)	-0.332	[-0.579, -0.085]	0.008	63.83%
RT Positive vs. Negative – Goal-relevant subgroup				
Main analysis	0.758	[0.190, 1.326]	0.009	96.71%
Case removed (Gutierrez-Cobo et al., 2017)	0.355	[0.185, 0.524]	< .0001	59.62%
RT Positive vs. Negative – Goal-irrelevant subgroup				
Main analysis	0.402	[-0.143, 0.947]	0.148	86.44%
Case removed (Zhang et al., 2020)	0.103	[-0.095, 0.300]	0.308	0%

Note. The “Main analysis” rows report pooled effect sizes including all studies. The “Case removed” rows report pooled effect sizes recalculated after exclusion of the identified influential studies (indicated in parentheses), as also reported in Table 7. Effect sizes are expressed as Hedges' g under a random-effects model. Bold values indicate statistically significant results. Abbreviations: RT = reaction time; CI = confidence interval; I² = between-study heterogeneity.

residual heterogeneity was statistically significant (Table 7). Leave-one-out analyses did not identify influential studies.

3.4.8. Comparison of commission errors for neutral vs. negative facial expressions

The comparison of CE between neutral and negative facial expressions was restricted to the goal-relevant subgroup, as only two studies included goal-irrelevant conditions (Maxwell et al., 2005; Yeung et al., 2024), precluding subgroup analysis. The final pooled analysis (Table 7 and Fig. 13), conducted after exclusion of Gutierrez-Cobo et al. (2017) and Schulz et al. (2009) as influential studies (see Table 10 and Table S17), indicated that emotional valence did not significantly affect CE when emotional stimuli were goal-relevant. Heterogeneity was reduced following sensitivity analyses, but remained substantial (see Table 7).

Among the two studies including goal-irrelevant stimuli, Maxwell et al. (2005) reported a significant difference between neutral and negative faces, whereas Yeung et al. (2024) found no significant difference.

3.4.9. Comparison of commission errors for neutral vs. positive facial expressions

The comparison of CE between neutral and positive facial expressions was restricted to the goal-relevant subgroup, as no studies examined CE under goal-irrelevant conditions. The final pooled analysis (Table 7 and Fig. 14), conducted after exclusion of Gutierrez-Cobo et al. (2017) and Schulz et al. (2009) as influential studies (see Tables 10 and S18), indicated that emotional valence did not significantly affect CE when emotional stimuli were goal-relevant. Heterogeneity was reduced following sensitivity analyses, but remained substantial (see Table 7).

3.4.10. Comparison of commission errors for positive vs negative facial expressions

The comparison of CE between positive and negative facial expressions was restricted to the goal-relevant subgroup, as only one study included a goal-irrelevant condition (Zhang et al., 2020). The final pooled analysis (Table 7 and Fig. 15), conducted after exclusion of Gutierrez-Cobo et al. (2017) as influential (see Tables 10 and S19), indicated that emotional valence did not significantly affect CE when emotional stimuli were goal-relevant. Heterogeneity was reduced following sensitivity analyses, but remained substantial (see Table 7).

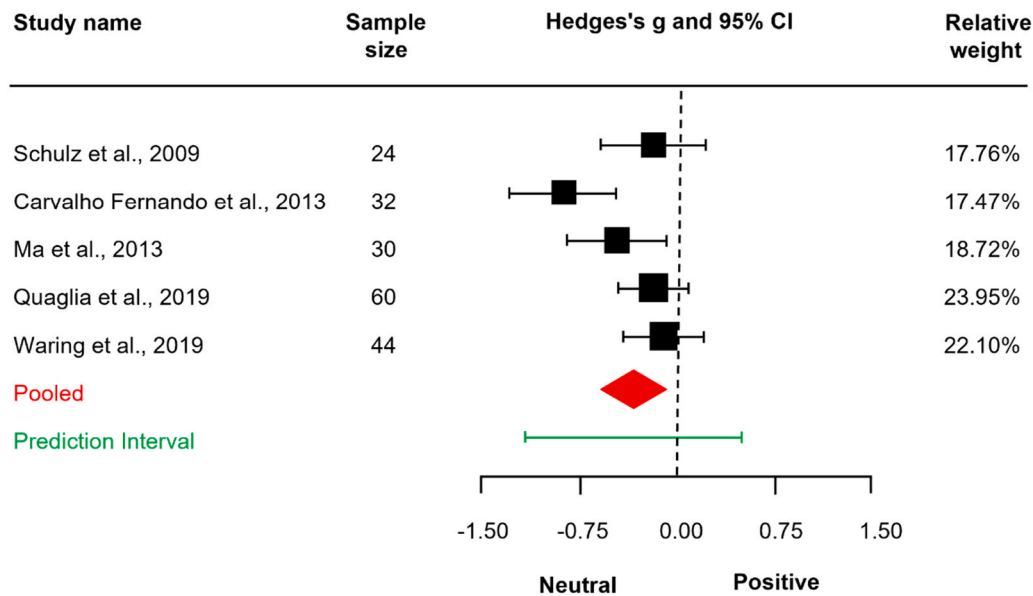


Fig. 8. Forest plot of random-effects meta-analysis comparing reaction times (RT) for neutral versus positive facial expressions within go-trials in goal-relevant studies. Positive values indicate longer RT for positive relative to neutral faces; negative values indicate longer RT for neutral relative to positive faces; all other conventions are as in Fig. 3.

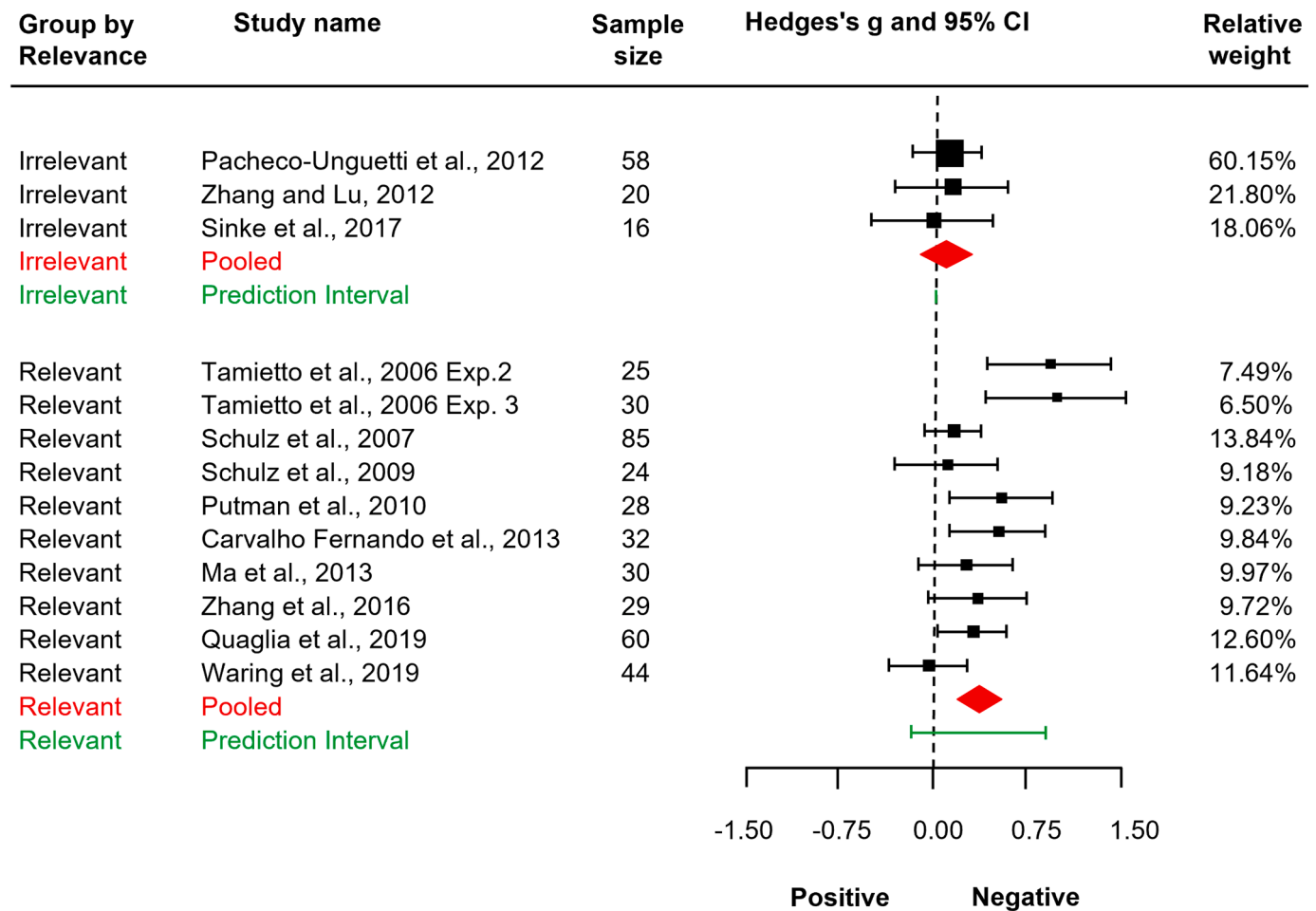


Fig. 9. Forest plot of random-effects meta-analysis comparing reaction times (RT) for positive versus negative facial expressions within go-trials, stratified by goal-relevance. Positive values indicate longer RT for negative relative to positive faces; negative values indicate longer RT for positive relative to negative faces; all other conventions are as in Fig. 3.

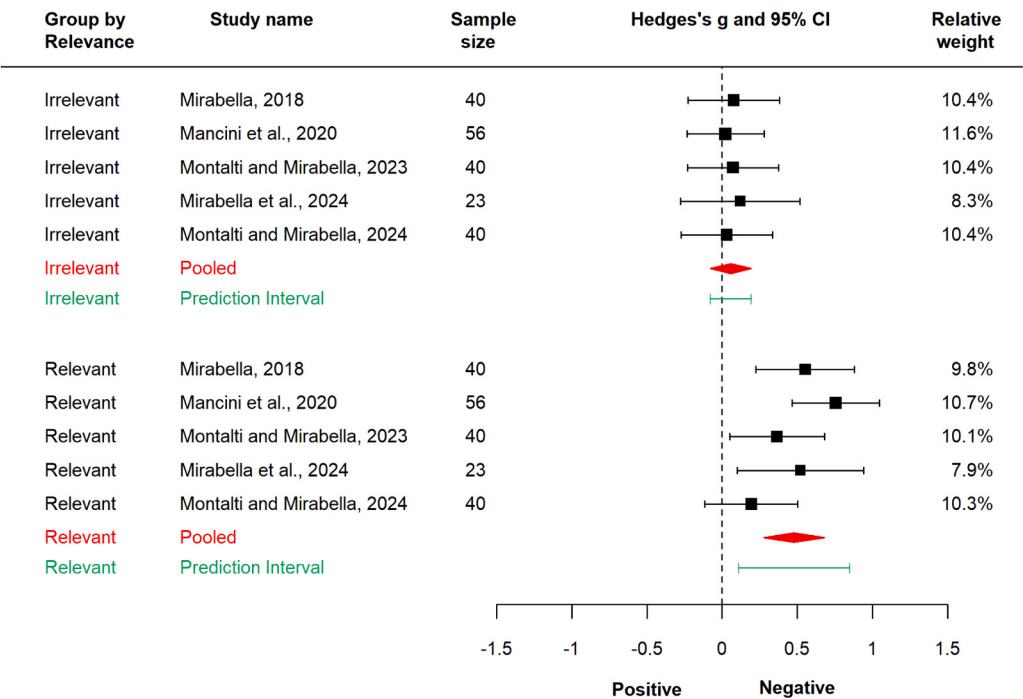


Fig. 10. Forest plot of random-effects meta-analysis comparing reaction times (RT) for positive versus negative facial expressions within go-trials, stratified by goal-relevance in within-subjects design studies. Positive values indicate longer RT for negative relative to positive faces, whereas negative values indicate longer RT for positive relative to negative faces. All other conventions are as in Fig. 3.

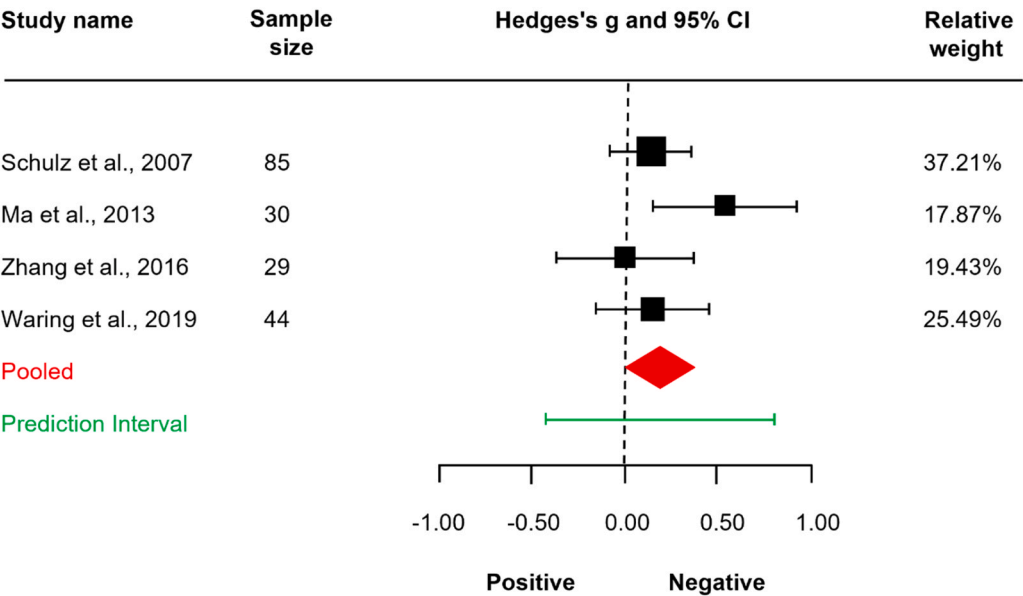


Fig. 11. Forest plot of random-effects meta-analysis comparing omission errors (OE) for positive versus negative facial expressions in goal-relevant studies. Positive values indicate higher OE for negative relative to positive faces; negative values indicate higher OE for positive relative to negative faces; all other conventions are as in Fig. 3.

Zhang et al. (2020), the only study examining goal-irrelevant stimuli, reported a significant increase in CE for negatively relative to positively valenced faces. In contrast, the only study employing a within-subject design (Mancini et al., 2022) found that negative (fearful) expressions were associated with reduced CE compared to positive expressions, but only when emotional cues were task-relevant.

3.4.11. Publication bias in studies using the Go/No-Go task

Publication bias was assessed visually through inspection of funnel

plots and analytically using the trim-and-fill procedure across all GNG meta-analyses. Visual inspection of the funnel plots suggested varying degrees of asymmetry across outcomes and facial expression contrasts. In several analyses, studies appeared unevenly distributed around the pooled effect size, particularly in comparisons characterized by substantial heterogeneity. However, given the high levels of between-study variability observed in most models, visual asymmetry should be interpreted cautiously, as heterogeneity may contribute to funnel plot distortion independent of publication bias. When asymmetry was

Table 9

Sensitivity analyses of pooled OE effect sizes before and after exclusion of the influential study.

	Hedges' g	95% CI	p-value	I ²
OE Positive vs. Negative – Goal-relevant subgroup				
Main analysis	−0.037	[−0.449, 0.375]	0.860	87.33%
Case removed	0.197	[0.016, 0.378]	0.033	37.71%
(Schulz et al., 2009)				

Note. The “Main analysis” row reports pooled effect sizes including all studies. The “Case removed” row reports pooled effect sizes recalculated after exclusion of the identified influential studies (indicated in parentheses). Effect sizes are expressed as Hedges’ g under a random-effects model. Bold values indicate statistically significant results. OE= Omission Error; CI= Confidence Interval, I² = between-study heterogeneity.

detected by statistical tests ($p < .05$; see Table 7), the trim-and-fill procedure was applied to estimate the number of potentially missing studies and to compute adjusted pooled effect sizes. In most comparisons, the adjusted estimates did not substantially differ from the original pooled effects, indicating a limited impact of potential small-study effects on the overall conclusions, and the trim-and-fill procedure did not identify any missing studies. In cases where adjustments were observed, changes in the magnitude of the effect size did not materially alter the statistical interpretation of the findings.

Overall, although some evidence of asymmetry was detected in selected analyses, there was no consistent indication that publication bias meaningfully influenced the pattern of results across GNG outcomes. Nevertheless, these findings should be interpreted with caution, given the relatively small number of studies included in several comparisons and the high heterogeneity observed.

For the studies using a within-subject design, the analysis of the publication bias was not conducted, as they all originate from the same research group (Sterne et al., 2011; Fig 16).

3.5. Comprehensive summary of results

Table 11 summarizes meta-analytic findings across all behavioral parameters. Effects of facial emotional valence were observed across several outcome measures when facial expressions were task-relevant, whereas no significant effects were reported when facial expressions were task-irrelevant. A descriptive tally suggests that approximately 60% of task-relevant contrasts were significant; however, this observation is descriptive and should not be interpreted, as the summarized comparisons are not independent, with identical contrasts (e.g., positive vs. negative) appearing multiple times across study designs (single-group, between-subject, and within-subject designs) and outcome measures (e.g., RT, OE), and with some contrasts not available (i.e., N/A). Nevertheless, the overall pattern in the Go/No-Go and Stop-Signal paradigms suggests that emotional valence effects are more consistently observed when emotional information is relevant for response selection. Variability was higher in task-relevant conditions, indicating that effect sizes are moderated by task demands and contextual factors. In contrast, consistently low variability in task-irrelevant conditions suggests that null effects are unlikely to reflect random noise. Within-subject designs yielded more robust and consistent effects, likely reflecting increased statistical power and reduced inter-individual variability.

4. Discussion

The present meta-analysis examined whether emotional facial expressions influence motor behavior differently depending on whether emotional information is goal-relevant or goal-irrelevant. Across studies of healthy young adults, emotional valence effects were more consistently observed when emotional information was required for response selection than when it was incidental to task goals. These findings indicate that emotional facial expressions exert reliable but context-dependent influences on response readiness and inhibitory control.

Before considering the broader theoretical implications of these findings, it is important to acknowledge the differences between the

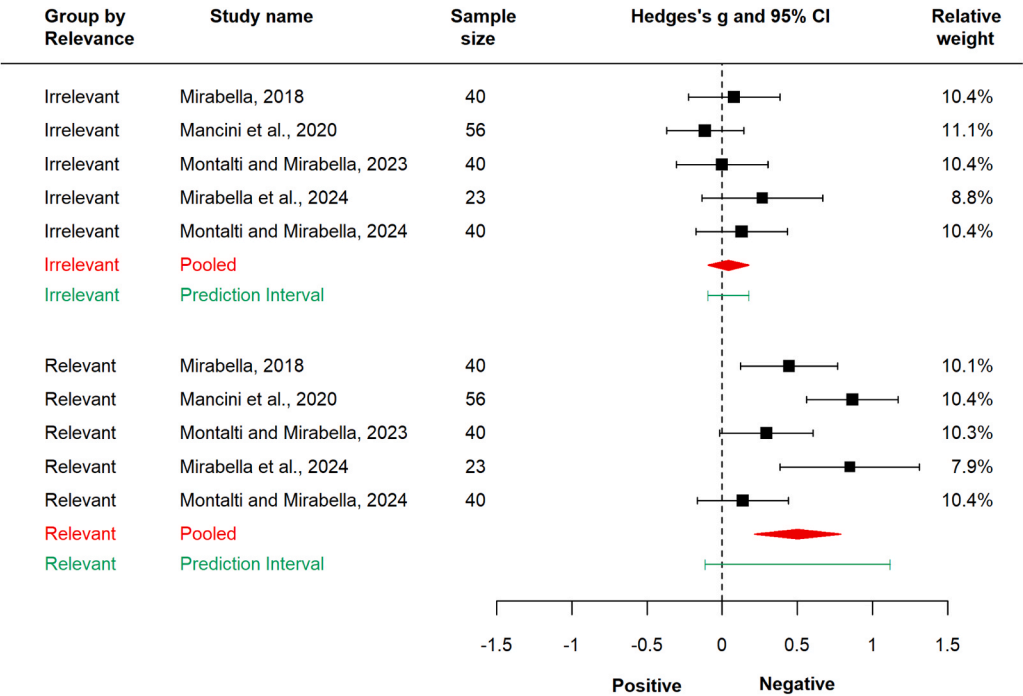


Fig. 12. Forest plot of random-effects meta-analysis comparing omission errors (OE) for positive versus negative facial expressions, stratified by goal-relevance in within-subject design studies. Positive values indicate higher OE for negative relative to positive faces, whereas negative values indicate higher OE for positive relative to negative faces. All other conventions are as in Fig. 3.

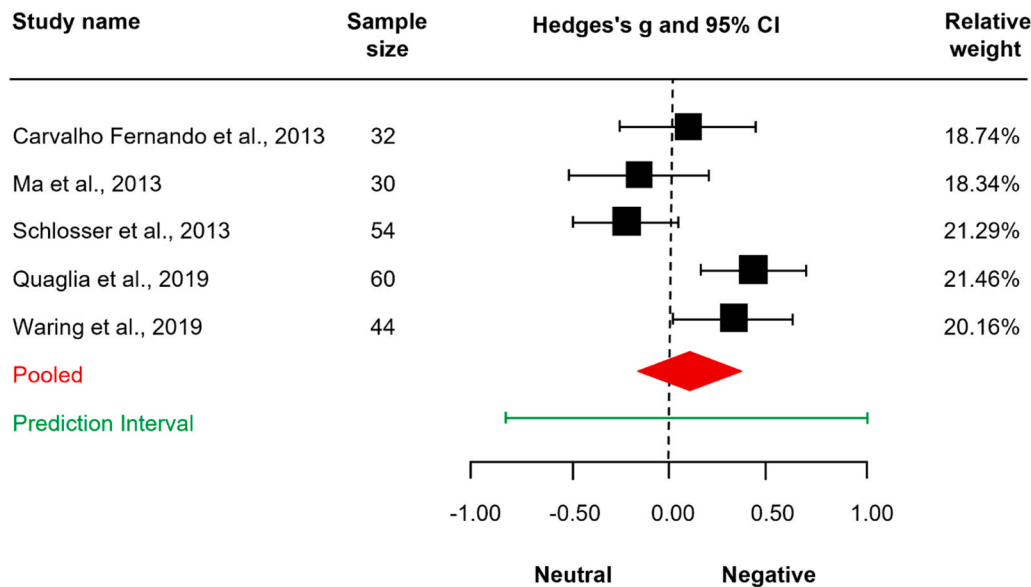


Fig. 13. Forest plot of random-effects meta-analysis comparing commission errors (CE) for neutral versus negative facial expressions in goal-relevant studies. Positive values indicate higher CE for negative relative to neutral faces; negative values indicate higher CE for neutral relative to negative faces; all other conventions are as in Fig. 3.

Table 10
Sensitivity analyses of pooled CE effect sizes before and after exclusion of the influential study.

	Hedges' g	95% CI	p-value	I ²
CE Neutral vs. Negative – Goal-relevant subgroup				
Main analysis	-0.832	[-1.784, 0.121]	0.087	98.24%
Cases removed (Gutierrez-Cobo et al., 2017; Schulz et al., 2009)	0.102	[-0.161, 0.364]	0.449	73.98%
CE Neutral vs. Positive – Goal-relevant subgroup				
Main analysis	-2.135	[-3.402, -0.868]	0.001	98.72%
Cases removed (Gutierrez-Cobo et al., 2017; Schulz et al., 2009)	0.166	[-0.322, 0.654]	0.504	91.86%
CE Positive vs. Negative – Goal-relevant subgroup				
Main analysis	0.732	[0.117, 1.348]	0.020	97.53%
Case removed (Gutierrez-Cobo et al., 2017)	-0.073	[-0.254, 0.108]	0.429	71.45%

Note. The “Main analysis” rows report pooled effect sizes including all studies. The “Case removed” rows report pooled effect sizes recalculated after exclusion of the identified influential studies (indicated in parentheses). Effect sizes are expressed as Hedges’ g under a random-effects model. Bold values indicate statistically significant results. Abbreviations: OE= Omission Error; CI= Confidence Interval, I² = between-study heterogeneity.

GNG and SST paradigms. The GNG primarily measures action restraint and, when emotional stimuli serve as go-signals, can also index response readiness. In contrast, the SST measures action cancellation and does not provide a comparable measure of response readiness, as stopping performance is typically controlled via a staircase-tracking procedure. Despite these mechanistic differences, the central pattern observed across both paradigms was broadly consistent: emotional valence influenced behavioral performance primarily when emotional information was relevant to task goals. Thus, our conclusions concern a common role of goal-relevance in shaping emotional influences on action control, while acknowledging that the specific cognitive processes affected may differ between the GNG and SST paradigms.

The present findings broadly suggest that evidence for enhanced

neural processing of emotional stimuli should not be interpreted as evidence of behavioral consequences. Although emotional stimuli may engage neural systems that bias perception and attention (Ishai et al., 2004; Lavie, 2005; Pessoa and Adolphs, 2010; Pessoa and Ungerleider, 2004; Pourtois et al., 2013), such processing does not appear sufficient, by itself, to produce reliable effects on motor behavior. Rather, emotional valence effects emerged most consistently when emotional information was relevant for selecting an appropriate response. This interpretation is consistent with accounts emphasizing top-down modulation of emotional processing (Maxwell et al., 2025; Mirabella and Montalti, 2025), according to which the behavioral consequences of emotional stimuli depend on their relationship to current task demands. Importantly, the present findings extend those of Maxwell et al. (2025) from the domain of attention to the domain of action control. Whereas Maxwell et al. (2025) showed that emotional facial expressions produced negligible effects on spatial attention when task-irrelevant but substantially larger effects when task-relevant, the present meta-analysis revealed a comparable pattern for response readiness and inhibitory control. Together, these findings suggest that the behavioral consequences of emotional facial expressions depend less on their emotional content per se than on the extent to which that information is relevant to current goals.

The robustness of these conclusions is further supported by the absence of clear evidence for publication bias. The present analyses revealed no consistent indication that publication bias meaningfully influenced the findings, increasing confidence in the conclusions drawn. In many areas of science, dominant theoretical frameworks are associated with preferential reporting of confirmatory evidence, with positive findings more likely to be published and null results underreported (Franco et al., 2014; Munafò et al., 2017; Open Science Collaboration, 2015). Fortunately, such a pattern was not evident here. One plausible explanation is that a substantial proportion of studies (~37.9%) were designed primarily to investigate neural responses to emotional stimuli rather than behavioral outcomes per se. In fact, ~54.5% of those studies reported null behavioral findings alongside neural effects, thereby reducing the selective non-reporting of non-significant results. This interpretation is speculative, however, and should be considered cautiously.

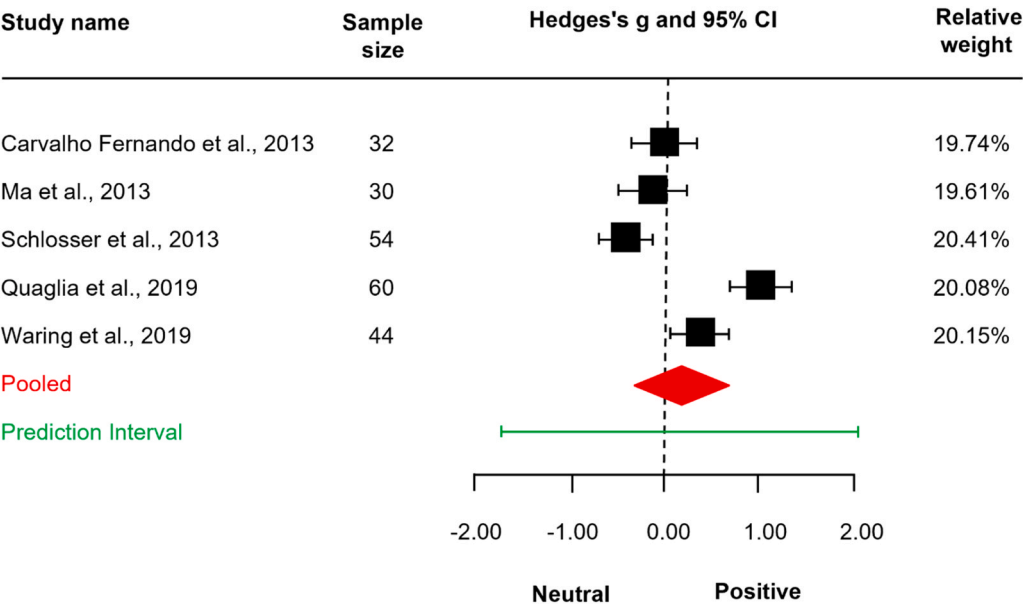


Fig. 14. Forest plot of random-effects meta-analysis comparing commission errors (CE) for neutral versus positive facial expressions in goal-relevant studies. Positive values indicate higher CE for positive relative to neutral faces; negative values indicate higher CE for neutral relative to positive faces; all other conventions are as in Fig. 3.

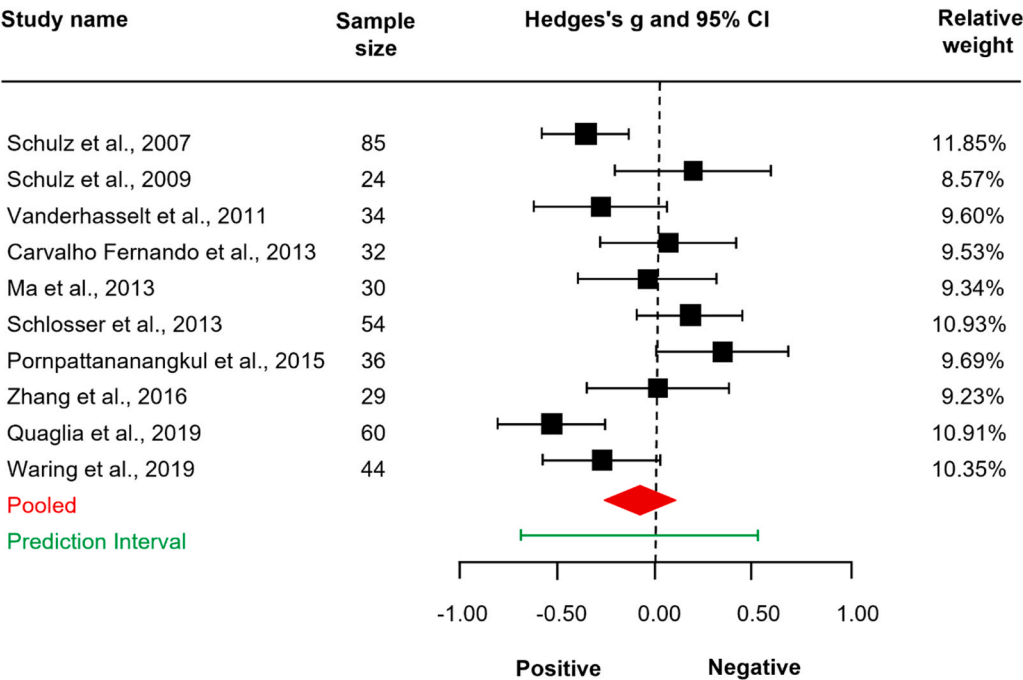


Fig. 15. Forest plot of random-effects meta-analysis comparing commission errors (CE) for positive versus negative facial expressions in goal-relevant studies. Positive values indicate higher CE for negative relative to positive faces; negative values indicate higher CE for positive relative to negative faces; all other conventions are as in Fig. 3.

4.1. Why does goal-relevance matter?

The present findings place important constraints on accounts that construe emotions as either mediators or moderators of behavior. In particular, the prevailing absence of effects on response inhibition or response readiness when facial expressions are task-irrelevant is difficult to reconcile with standard evolutionary accounts that assume relatively direct or automatic links between emotional stimuli and behavioral responses (Bradley et al., 2001; Lang and Bradley, 2010). Such accounts would predict that biologically salient stimuli, such as emotional facial

expressions, influence these behaviors independently of their task relevance. The present data do not support this prediction. Evolutionary accounts could accommodate the present findings only by assuming that emotional stimuli influence behavior after their biological or motivational significance has been evaluated (e.g., whether they signal threat; LeDoux, 2012; Öhman and Mineka, 2001). However, introducing such an evaluative stage moves these accounts closer to appraisal theories, which likewise posit that behavioral responses depend on an assessment of the significance of the stimulus before action is selected, although appraisal theories emphasize the significance of the stimulus with

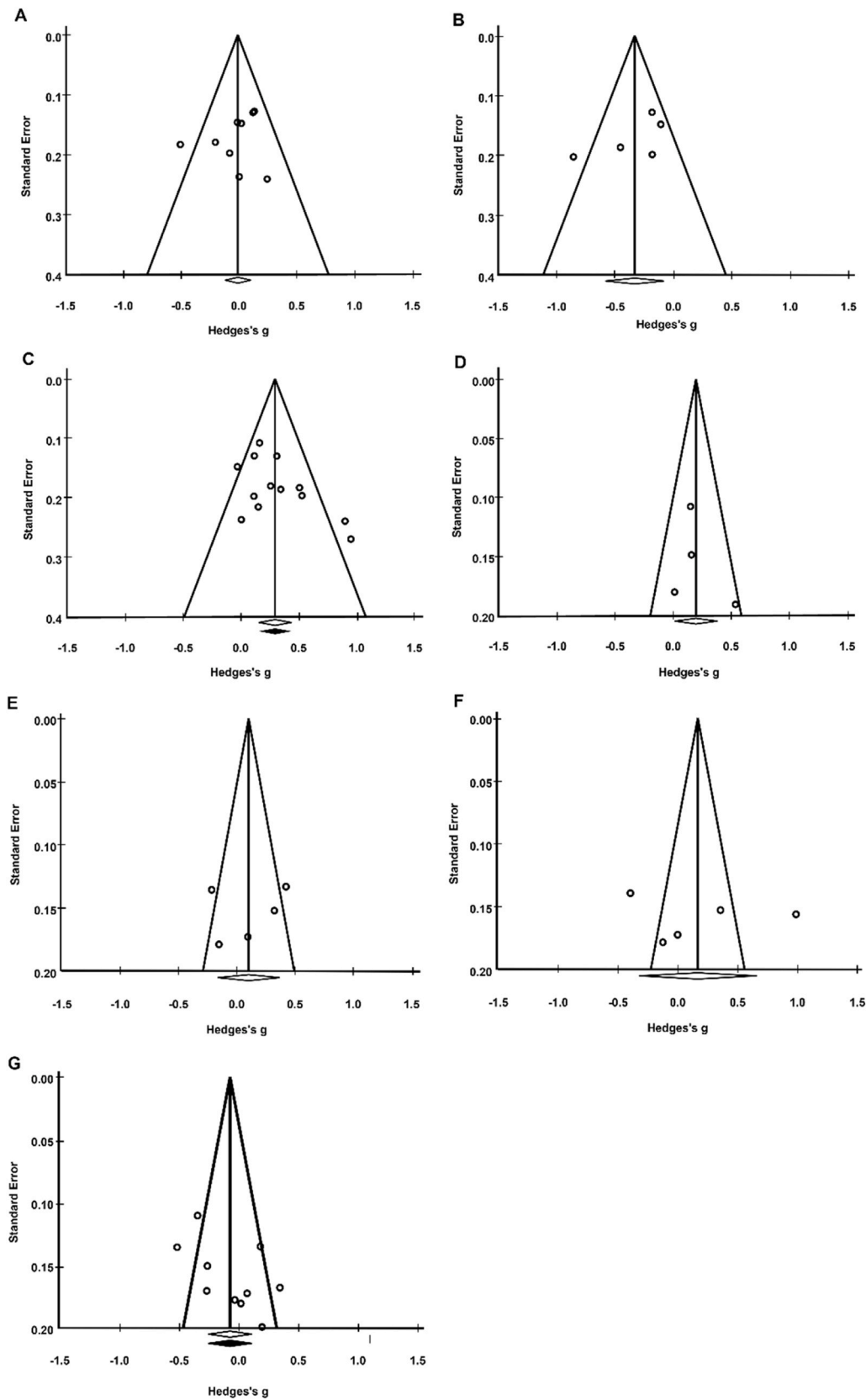


Fig. 16. Funnel plots for meta-analyses of Go/No-Go outcomes across facial expression comparisons. Panels depict (A) Reaction times (RT) neutral vs. negative, (B) RT neutral vs. positive, (C) RT positive vs. negative, (D) Omission errors (OE) positive vs. negative, (E) Commission errors (CE) neutral vs. negative, (F) CE neutral vs. positive, and (G) CE positive vs. negative. The x-axis represents Hedges' g , and the y-axis represents the standard error. Each point corresponds to an individual study. The vertical line indicates the pooled effect estimated using a random-effects model, with the open diamond representing its 95% confidence interval. The filled diamond indicates the trim-and-fill adjusted pooled effect size; as no studies were imputed, it overlaps with the original estimate. Diagonal lines denote the expected distribution of studies in the absence of publication bias.

Table 11

Summary of meta-analytic findings across emotional contrasts and goal-relevance conditions.

	Task-relevant	Variability	Task-irrelevant	Variability
Stop-signal Reaction Time				
Neutral vs. Negative*	Significant	Low/ Negligible	n.s	High
Neutral vs. Positive	N/A	N/A	n.s	Low
Positive vs. Negative	N/A	N/A	n.s	Moderate
Go-trials Reaction Time				
Neutral vs. Negative [§]	n.s	Moderate	n.s	Low/ Negligible
Neutral vs. Positive	Significant	Moderate/ High	N/A	N/A
Positive vs. Negative [§]	Significant	Moderate	n.s	Low/ Negligible
Positive vs. Negative* (Within-subject design)	Significant	-	n.s	Low/ Negligible
Go-trials Omission Errors				
Positive vs. Negative	Significant	Low/ Moderate	N/A	N/A
Positive vs. Negative* (Within-subject design)	Significant	-	n.s	Moderate
No-go trials Commission Errors				
Neutral vs. Negative	n.s	High	N/A	N/A
Neutral vs. Positive	n.s	High	N/A	N/A
Positive vs. Negative	n.s	High	N/A	N/A

Note. Variability was classified primarily based on I^2 as low (<25%), moderate (25% to <75%), or high ($\geq 75\%$), with Cochran's Q and τ^2 reported as complementary indices of heterogeneity. For multilevel models, the reported I^2 reflects total heterogeneity. Intermediate labels (e.g., low/moderate, moderate/high) were used when I^2 values approached the boundaries between these ranges. Significant effect sizes (Hedges' g) are indicated in bold. The asterisk (*) indicates a significant test of moderators, whereas the § indicates a non-significant test. Abbreviations: N/A = not available; n.s. = non-significant.

respect to the organism's current goals rather than solely its biological significance (Moors et al., 2013).

Appraisal theories are, in principle, compatible with the present results, as they assume that stimuli are continuously evaluated for their relevance and can accommodate a threshold mechanism whereby only sufficiently goal-relevant stimuli undergo further processing (Moors et al., 2013; Scherer and Moors, 2019). However, this interpretation requires additional assumptions about how such relevance thresholds are implemented, which are not always explicitly specified. Moreover, construing emotions as moderators that bias ongoing decision processes would predict graded effects across conditions, which is inconsistent with the all-or-nothing pattern observed here.

By contrast, the findings are more directly captured by goal-directed accounts (Moors et al., 2017; Moors and Fischer, 2019), according to which behavior is governed by the evaluation of stimulus-goal discrepancies, goal values, and response-outcome expectancies. Within this framework, stimuli influence action only insofar as they are integrated into the current goal structure, such that goal-irrelevant stimuli have no impact on behavior. A similar interpretation is offered by constructionist theories of emotion (Barrett, 2012; Lindquist and Barrett, 2012), which do not posit emotions as distinct causal entities but instead conceptualize behavior as emerging from context-dependent processes of meaning construction. From this perspective, the absence of effects for goal-irrelevant facial expressions follows naturally, without requiring dedicated emotion-specific mechanisms. More generally,

these accounts provide a more parsimonious and unified explanation of the present behavioral findings, insofar as they capture the role of task relevance within domain-general goal-directed processes rather than invoking emotions as separate determinants of behavior.

More broadly, the present findings complement contemporary accounts emphasizing interactions between emotion and attention (Pessoa, 2009; Pessoa and Adolphs, 2010; Pessoa and Ungerleider, 2004; Pourtois et al., 2013). These frameworks have shown that the processing of emotional stimuli depends on attentional demands and available cognitive resources, but they do not specify the conditions under which such processing translates into measurable behavioral consequences. The present meta-analysis addresses this latter question by showing that emotional information influences response readiness and inhibitory control primarily when it is required for selecting an appropriate response. Thus, the critical issue is not simply whether emotional stimuli are processed, but whether the information they convey is relevant for guiding action. In this sense, goal relevance appears to constitute an important determinant of when emotional processing influences overt behavior.

Importantly, the absence of consistent behavioral effects under goal-irrelevant conditions should not be interpreted as evidence that emotional stimuli fail to undergo perceptual or neural processing. A large body of research demonstrates that emotionally salient stimuli can elicit rapid and automatic changes in neural activity even when they are not relevant to current task goals (Carretié et al., 2021; Gur et al., 2002b; Montalti and Mirabella, 2024; Sagaspe et al., 2011). Rather, the present findings suggest that such neural responses are not, by themselves, sufficient to reliably influence overt behavior. In other words, the presence of emotion-related brain activity does not necessarily imply corresponding changes in response readiness or inhibitory control. Instead, behavioral consequences appear to emerge most consistently when emotional information is integrated with task goals and response requirements.

Overall, the present findings support the view that motor response readiness and behavioral response inhibition are governed by goal-directed processes, insofar as facial expressions influenced motor responses only when they were relevant to the current task goals. This interpretation is further supported by recent meta-analytic evidence from visual search paradigms, suggesting that apparent attentional capture by emotional faces depends critically on their task relevance (Maxwell et al., 2025). When emotional stimuli match the current search strategy or task demands, robust effects emerge; however, when they are truly task-irrelevant, such effects are minimal or absent.

Within this framework, heterogeneous results can be understood in terms of how stimulus-goal discrepancies, goal values, and response-outcome expectancies are represented and evaluated. In the study participant's present task, the goal of responding correctly on the experimental task is consistently high in value, such that differences in behavior are best explained by whether stimuli are integrated into the current goal structure, rather than by variations in goal importance per se. This perspective obviates the need to posit emotions as distinct causal entities, since the observed effects can be accounted for by domain-general mechanisms that govern goal-directed action.

4.2. Goal-relevance effects in within-subject designs

Because responses to emotional stimuli vary substantially across individuals as a function of personality traits (Canli et al., 2001; Dolcos et al., 2020), within-subject designs provide a particularly rigorous test of whether task relevance influences behavior by controlling for stable interindividual differences.

Among the included studies, only eight used a within-subject design: one employed the SST and seven employed the GNG task (Mancini et al., 2020, 2022; Mirabella, 2018; Mirabella et al., 2024b; Montalti and Mirabella, 2023, 2024; Yu et al., 2017). Due to the limited number of within-subject studies, meta-analyses on emotional valence could only

be conducted for the same contrast across two behavioral parameters (RT and OE; see Table 11). These analyses yielded consistent results, with significant effects observed only for task-relevant contrasts, and task relevance emerged as a significant moderator. The relatively low heterogeneity suggests that these effects are unlikely to reflect random noise (Table 7). Furthermore, negative facial expressions were associated with increased RT and higher OE rates compared to positive facial expression, a pattern consistent with delayed attentional disengagement from task-relevant negative stimuli. Although further evidence is needed, this approach appears promising for future research.

4.3. Limitations for identifying effects of goal-relevance of emotion

4.3.1. Structural limitations of the available evidence

The overall pattern of findings should be interpreted in light of several important structural limitations of the available evidence. First, a substantial proportion of theoretically possible meta-analytic comparisons (11 out of 24) across outcome measures could not be estimated due to an insufficient number of studies or their missing specific emotional valence contrast $\times$ task relevance condition combinations. This results in an uneven coverage of the evidence base across behavioral domains and goal-relevance conditions, limiting the generalizability of the conclusions.

Second, within-subject designs, arguably providing the most sensitive test of goal-relevance effects, were available only for a restricted subset of comparisons, primarily related to response readiness, and were entirely absent for reactive inhibitory control. Consequently, the strength of inference varies across outcomes, with more robust evidence for response readiness than for inhibitory control.

4.3.2. Methodological limitations of the available evidence

In addition to structural limitations, some methodological characteristics of the selected studies constrain interpretation. First, the arousal dimension of emotional stimuli was frequently neglected, despite evidence suggesting that arousal may modulate behavioral responses (Bradley et al., 2001; Lang and Bradley, 2010; Lundqvist et al., 2014). Specifically, 24 out of 42 studies (57.1%) did not assess arousal, and an additional seven studies (16.7%) reported differences in arousal between emotional conditions but did not incorporate this factor into their statistical analyses (Battaglia et al., 2022; Ding et al., 2020; Gupta and Singh, 2021, 2023; Lodha and Gupta, 2024; Ma et al., 2013; Song et al., 2016). As a result, in 73.8% of the studies, it remains unclear whether observed effects can be attributed to emotional valence, arousal, or their interaction. In the remaining studies (26.2%), arousal was either explicitly controlled at the design level, with no differences in arousal between experimental conditions (14.3%; Mirabella, 2018; Vanderhasselt et al., 2011; Yu et al., 2017; Zhang et al., 2016; Zhang et al., 2020; Zhang and Lu, 2012) or was formally included as an experimental factor in the statistical analyses (11.9%; Mancini et al., 2020, 2022; Mirabella et al., 2024b; Montalti and Mirabella, 2023; Montalti and Mirabella, 2024), and found not to influence response readiness and inhibition. Although these findings suggest that arousal may not substantially influence behavioral outcomes under the specific conditions examined, the limited number of such studies precludes firm conclusions. Consequently, because arousal was not adequately assessed or controlled in the majority of the literature, its contribution to the reported behavioral effects cannot be determined with confidence. In future research, a more systematic assessment of arousal, valence, and their interaction would improve the interpretability of behavioral outcomes.

A second limitation concerns the treatment of negative emotions as a single valence category. Although discrete negative emotions, such as fear, anger, sadness, and disgust, may differ in their motivational significance and behavioral consequences, the available literature does not provide sufficient evidence to examine these emotions separately in most comparisons. Exploratory analyses, conducted whenever feasible,

were limited by the small number of available studies and did not permit firm conclusions regarding effects of discrete negative emotions. Accordingly, the present findings should be interpreted as applying to negative emotional valence as a broad category rather than to specific negative emotions. Future research directly comparing discrete emotions within the same experimental paradigms will be important for determining whether goal relevance differentially modulates their behavioral effects.

Third, when reactive inhibition was indexed by CE rates, meta-analytic comparisons consistently yielded non-significant effects of emotional valence under task-relevant conditions, accompanied by substantial between-study variability. This pattern likely reflects the limited sensitivity of commission errors as an index of reactive inhibition within the GNG paradigm. Specifically, the proportion of no-go trials is typically low (e.g., 25–33%) to induce a prepotent tendency to respond (Wessel, 2018; Young et al., 2018). As a consequence, CE are relatively infrequent, and estimates are derived from a limited number of trials. Given an average ($\pm$ SD) CE rate of $12.8 \pm 6.4\%$ across studies, this results in low measurement precision and increased susceptibility to noise, thereby inflating variability and reducing the likelihood of detecting systematic effects. Notably, this pattern changes when more sensitive within-subject designs are employed, thereby reducing inter-individual variability and increasing statistical power. In addition, these designs compare conditions within highly matched task contexts (e.g., identical stimuli and response requirements differing only in goal-relevance), thereby minimizing methodological variability across conditions. Under these conditions, Mancini et al. (2022), using facial expressions, and Calbi et al. (2022), using body postures, both reported lower CE rates for negative (fearful) relative to positive (happy) stimuli in task-relevant conditions, whereas no differences emerged when emotional facial expressions were task-irrelevant. These findings suggest that the lack of an effect for the CE in the meta-analysis is unlikely to constitute strong evidence for the absence of an underlying behavioral effect.

4.4. Future directions for the field

Building on the limitations considered above, several directions for advancing research on emotion–action interactions emerge. A first issue concerns the ecological validity of the emotional stimuli employed. The predominant use of static, decontextualized facial expressions provides a simplified representation of emotional signals (Holleman et al., 2021; Shamay-Tsoory and Mendelsohn, 2019), whereas in natural settings these signals are dynamic and embedded within complex social environments (Aviezer et al., 2017). Emotional meaning typically arises from the integration of multiple sources of information, including body cues and situational context, which are largely absent in current paradigms. This limitation raises the possibility that existing findings may provide an incomplete characterization of how emotional information influences motor behavior. In the future, approaches that incorporate more naturalistic and interactive contexts, such as immersive virtual environments, may therefore offer a more comprehensive characterization of these processes (González-Gualda et al., 2024).

A second issue concerns the role of individual differences in modulating the effects of goal relevance. The observation that effects of emotional facial expressions emerge primarily under task-relevant conditions underscores the importance of experimental designs that can isolate such context-dependent modulation. Within-subject approaches appear particularly well suited in this regard, as they reduce between-participant variability and increase sensitivity to subtle effects. At the same time, individual differences represent an additional source of variability that remains largely unexamined in the studies assessed in the present meta-analysis. Factors such as personality traits, emotion regulation strategies, and cultural background are likely to shape the processing of emotional information (Canli et al., 2001; Dolcos et al., 2020) and should be more systematically incorporated into future

investigations. In addition, the extent to which these findings generalize across the lifespan remains largely unexplored, but see Waring et al., (2019) and Williams et al., (2020) for initial investigations into this question. Future research should examine whether and how emotion-action interactions change from younger to older adulthood, as aging-related differences in cognitive control and emotional processing may systematically modulate these interactions (Charles and Carstensen, 2010; Ruffman et al., 2008).

Finally, the relationship between emotional processing and proactive inhibition has received no attention, despite its functional relevance and its documented alterations in clinical populations (Mirabella, 2021). Clarifying how emotional information influences proactive inhibitory control and its interaction with reactive inhibition represents an important direction for advancing current models.

From a methodological perspective, future work should strengthen the robustness of inferences by ensuring adequate statistical power and adopting analytical approaches capable of quantifying evidence for both null and alternative hypotheses, using, for instance, Bayesian statistics (Rouder and Morey, 2009; Rouder et al., 2012, 2009). Together, these advances will offer a more precise understanding of the conditions under which emotional information influences action.

4.5. Conclusions

The present meta-analysis provides quantitative evidence, consistent with two recent reviews (Maxwell et al., 2025; Mirabella and Montalti, 2025), that the impact of emotional facial expressions on response readiness and behavioral inhibition critically depends on their relevance to current goals. Emotional valence reliably modulates both response readiness and inhibitory control only when it is task-relevant, whereas no systematic effects emerge when emotional information is incidental. These findings challenge accounts positing obligatory responses to emotional stimuli and instead support a context-dependent framework in which emotion-action interactions are shaped by goal-directed processes, such that emotional information influences motor behavior only insofar as it is relevant to the individual's current goals.

A broader implication of the present findings concerns the distinction between neural and behavioral levels of analysis. Many influential theories and neuroscience studies infer privileged processing of emotional stimuli from enhanced neural responses. However, neural prioritization and behavioral prioritization are not equivalent phenomena. Enhanced neural activity may reflect the evaluation of biologically significant information without necessarily producing measurable changes in overt behavior. The present findings suggest that the translation of emotional signals into action depends critically on whether the emotional information is relevant to the individual's current goals. Accordingly, the widespread use of task-irrelevant emotional stimuli may provide only limited insight into the mechanisms through which emotion shapes behavior.

Importantly, establishing the conditions under which emotional information influences action in healthy individuals provides an essential normative framework for interpreting alterations observed in neuropsychiatric and neurological disorders. In this way, the present findings not only advance theoretical understanding of emotion-action interactions but also provide a foundation for future translational research.

Author contribution

Giovanni Mirabella conceived the study, secured funding, and supervised the project. Giovanni Mirabella and Valentina Maselli developed the methodology and conducted the investigation. Valentina Maselli performed the data curation, formal analyses, and visualization. Giovanni Mirabella and Valentina Maselli interpreted the results and wrote the original draft of the manuscript. Jill Waring contributed to the interpretation of the findings and critically revised the manuscript. All

authors reviewed, provided feedback, and approved the final version of the manuscript.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.neubiorev.2026.106881.

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