Neuroscience and Biobehavioral Reviews 176 (2025) 106289

Contents lists available at ScienceDirect

Neuroscience and Biobehavioral Reviews

journal homepage: www.elsevier.com/locate/neubiorev

# When do facial emotions impact inhibitory control and response readiness? A gateway to understanding emotion processing

Giovanni Mirabella [a,b,*], Martina Montalti [a]

[a] Department of Clinical and Experimental Sciences, University of Brescia, Brescia, Italy
[b] IRCCS Neuromed, Pozzilli, Italy

A R T I C L E  I N F O

*Keywords:*
Emotion
Go/No-go task
Stop-signal task
Task-relevance
Attention
Motor readiness
Inhibitory control

A B S T R A C T

For the past 25 years, it has been widely believed that humans react automatically to emotional stimuli, as such responses are thought to be crucial for survival. However, recent empirical evidence from studies with healthy individuals suggests that the emotional valence of stimuli influences motor behavior only when it aligns with the individual's goals. In this review, we focused on research examining whether, when, and how emotional facial expressions influence reactive motor inhibition and response readiness in healthy young adults depending on their relevance to current goals. Following PRISMA guidelines, we identified 52 studies using the Stop-signal tasks and Go/No-go task where participants responded with their hands or arms. After excluding 10 low-quality studies, 42 articles were retained for inclusion in our review. By selecting this subset of studies, we aimed to ensure consistency and comparability in the research. Despite the presence of several confounding factors that limit the interpretability of the findings, our results suggest that emotional stimuli do not influence motor behavior when they are irrelevant to the task. In contrast, when the emotional content is relevant to the task, the valence of emotional expressions tends to impact behavior. This effect is particularly evident in studies that employed within-subjects designs allowing to control for interindividual variability ($n = 7$). While further research is certainly needed, the current evidence suggests that emotional expressions do not automatically elicit behavioral responses. Instead, individual's current goals appear to play a pivotal role in determining how people respond to facial emotions.

## 1. Introduction

Emotions are multi-component processes involving both conscious and unconscious aspects, triggered by external stimuli (such as seeing an angry person) or internal motivations (like the desire for pleasure). They give rise to physiological and motor responses, along with mental states that are typically referred to as feelings (McRae and Gross, 2020; Scherer and Moors, 2019).

In this review, we will focus on one aspect of how the brain processes emotions, specifically examining our behavioral responses to external emotional stimuli. For about 25 years evolutionary theories, exemplified by the motivational model (Bradley et al., 2001; Lang and Bradley, 2010; Lang et al., 1997), argue that our attentional system cannot filter stimuli laden with emotional value (Vuilleumier, 2005). Therefore, even though these stimuli are irrelevant to the subjects' current goals, if they are sufficiently salient, they trigger swift and automatic behavioral responses designed to improve survival. For instance, the motivational model postulates that positive-valenced stimuli, those promoting an organism's survival and procreation, trigger an appetitive motivational system boosting feeding, copulation, and caregiving behaviors. Conversely, negative-valenced stimuli, those threatening survival, trigger a defensive motivational system that enhances behaviors like withdrawal, escape, and aggression. The stimuli's arousal determines the activation level of these two systems, with highly arousing stimuli provoking stronger reactions, while low-arousing stimuli are less effective. Although this can be seen as a form of flexibility, it is driven by the characteristics of the stimuli rather than the individual's goals. As a result, evolutionary models, with their stimulus-driven logic, struggle to explain why the same emotional stimuli can lead to completely different emotional responses. For instance, encountering a cobra in the wild may trigger a fight-or-flight response, while observing the same snake under the control of a snake charmer may instead evoke fascination or pleasure. Recent studies offer a potential explanation for this apparent paradox by demonstrating that individuals are not merely passive

* Correspondence to: Department of Clinical and Experimental Sciences, Brescia University, Viale Europa, 11, Brescia 25123, Italy.
*E-mail address:* giovanni.mirabella@unibs.it (G. Mirabella).

https://doi.org/10.1016/j.neubiorev.2025.106289
Received 28 February 2025; Received in revised form 26 May 2025; Accepted 12 July 2025
Available online 14 July 2025

recipients of emotional stimuli. Instead, they actively interpret and assess emotionally significant information in ways that support their current goals (Calbi et al., 2022; Mancini et al., 2020, 2022; Mirabella, 2018; Mirabella et al., 2024a; Mirabella et al., 2023; Mirabella et al., 2024b; Montalti and Mirabella, 2023, 2024). This goal-driven modulation indicates that personal goals play a crucial role in emotional processing. This clear result reflects the use of an innovative experimental approach where motor readiness or inhibitory control of the same healthy individuals to identical emotional images were investigated using two counterbalanced versions of a Go/No-go task: the Emotion Discrimination Task (EDT) and the Control Discrimination Task (CDT). In the EDT, recognizing the presence of an emotion was essential for providing a correct response, whereas in the CDT, emotions were irrelevant to the task because participants responded based on a different feature of the same images, such as the poser's gender (Mancini et al., 2020, 2022; Mirabella, 2018; Mirabella et al., 2024a; Mirabella et al., 2023; Mirabella et al., 2024b; Montalti and Mirabella, 2023, 2024) or the color of a t-shirt (Calbi et al., 2022). In the EDT, the impact of emotional stimuli on response readiness was examined by using emotional expressions (fearful, angry, or happy) as go-signals, requiring participants to initiate a movement, while neutral faces served as no-go signals, instructing them to refrain from moving (Mancini et al., 2020; Mirabella, 2018; Mirabella et al., 2024a; Mirabella et al., 2024b; Montalti and Mirabella, 2023, 2024). Conversely, inhibitory control was assessed by reversing this setup, i.e., emotional expressions acted as no-go signals, requiring participants to withhold an arm movement, while neutral faces served as go-signals, prompting them to move (Calbi et al., 2022; Mancini et al., 2022).

When emotional expressions were task-relevant and acted as the go-signal, threatening expressions (angry or fearful) always increased the RT and the rate of omission errors with respect to positive faces (Mancini et al., 2020; Mirabella, 2018; Mirabella et al., 2024a; Mirabella et al., 2023; Mirabella et al., 2024b; Montalti and Mirabella, 2023, 2024). Instead, when threatening expressions acted as no-go signals they improve inhibitory control, as the rate of commission errors was smaller than for positive expressions, indicating that inhibitory control was improved (Calbi et al., 2022; Mancini et al., 2022). All differences disappeared in task-irrelevant contexts, i.e., in the CDT. In all studies, emotional stimuli, whether facial expressions (Mancini et al., 2020, 2022; Mirabella, 2018; Mirabella et al., 2024a; Mirabella et al., 2023; Mirabella et al., 2024b; Montalti and Mirabella, 2023, 2024) or body-posture expressions (Calbi et al., 2022) were presented at fixation. The differences observed in their effects on response readiness and inhibitory control were attributed to task-relevant threatening expressions delaying attentional disengagement, as individuals tend to monitor potential threats more closely than positive stimuli. A recent work strengthened this hypothesis showing that saccades (Mirabella et al., 2024a), i.e., a reliable proxy of attention, show the same behavior of reaching arm movements (Mancini et al., 2020, 2022; Mirabella, 2018; Montalti and Mirabella, 2023, 2024), keypresses (Calbi et al., 2022; Mirabella et al., 2024b), and gait movements (Mirabella et al., 2023). Importantly, this experimental design enabled the evaluation of identical emotional stimuli and motor responses in both task-relevant and task-irrelevant contexts without needing explicit perceptual judgments from participants. In fact, in the EDT, participants were simply instructed to move based on the presence or absence of emotional expressions, without needing to categorize them explicitly.

This evidence is robust for several reasons. First, a within-subject design was consistently used, with all participants completing both the EDT and CDT in a counterbalanced order. Second, the sample size was generally large, with more than 30 participants (Fagerland, 2012), except in one case where only 20 participants were recruited (Mirabella et al., 2023). Third, the effects of the same images were compared when they were task-relevant versus irrelevant. Fourth, stimulus arousal was carefully controlled, and it was shown not to influence the outcomes. Fifth, all statistically significant results demonstrated strong effect sizes. Sixth, Bayes factors were calculated in all but one case (Mirabella, 2018) and strongly supported: a) the differences between positive and negative stimuli in the EDT, and b) the absence of such differences in the CDT.

One potential counterargument is that these findings might be unique to the specific design described above. However, this is not the case, as other researchers, even under less controlled conditions, have arrived at similar conclusions using entirely different tasks that still follow within-subjects designs (Berger et al., 2017; Lichtenstein-Vidne et al., 2012; Mauersberger et al., 2024; Stein et al., 2009; Victeur et al., 2020).

Berger et al. (2017) examined how the task relevance of emotional faces influences a core executive function other than inhibitory control, specifically, working memory (Diamond, 2013). They gave two versions of a working memory task to 25 healthy young adults: one with a low memory load and another with a high memory load. In both tasks, participants were shown a sequence of face images that varied in age and expression (neutral, happy, or angry). In different blocks, they were required to assess either the emotion (when emotions were task-relevant) or the age (when emotions were task-irrelevant) of each face. Their task was to determine whether the relevant feature of the current face matched or did not match the image presented one step earlier (low-load) or two steps earlier (high-load) in the sequence. Berger et al. (2017) found that when emotions were task-relevant, positive facial expressions enhanced working memory performance, leading to greater accuracy and faster RT for happy faces compared to neutral and angry ones, regardless of the cognitive load. In contrast, when emotional content was task-irrelevant, facial expression valence had no effect on performance. The authors also controlled for arousal and ruled out the possibility that the results were driven by this aspect of emotional expressions. The only weak point of this study is that Bayes factors were not computed.

Stein et al. (2009) investigated the extent to which emotional facial expressions capture attention using three variations of the attentional blink task (Raymond et al., 1992). In all versions, the first target (T1) was a facial expression (neutral or fearful), while the second target (T2) was an indoor or outdoor scene. In the first version, participants judged the facial expression of T1 (making emotions task-relevant) and identified whether T2 depicted an indoor or outdoor scene. In the second version, participants identified T1's gender, while in the third, they were instructed to disregard T1 altogether. Therefore, in both of these versions, emotions were task-irrelevant. The results showed that when emotions were task-relevant, fearful faces reduced the accuracy of T2 categorization at short time lags compared to neutral faces. However, no such difference was found in the other two versions, where emotions were task-irrelevant. Stein et al. (2009) suggested that task-relevant fearful faces demand more attentional resources than neutral faces, reducing the capacity available for processing T2 stimuli presented shortly after T1. Two other studies using a between-subjects design reached the same conclusion: attention is allocated to emotional faces only when their emotional content is relevant to an individual's goals (Lichtenstein-Vidne et al., 2012; Victeur et al., 2020). Unfortunately, none of these studies accounted for the role of arousal, calculated effect sizes for post hoc tests, or reported Bayesian factors.

Finally, Mauersberger et al. (2024) examined the impact of task-relevant versus task-irrelevant emotional facial cues on facial mimicry in healthy participants. Imitating others' emotions plays a crucial role in social communication, facilitating emotional understanding and empathy, thereby fostering rapport and strengthening social connections (Fischer and Hess, 2017). The authors designed three versions of an affective priming paradigm in which two face images were presented sequentially. In two versions of the task, participants were instructed to attend exclusively to one face (either the first or the second) and categorize its emotional expression, while disregarding the other as task-irrelevant. In the third version, participants were asked to categorize the second face but also to attend to the first, which was not reported and thus remained task-irrelevant. Mauersberger et al. (2024)

found that only task-relevant faces, those that participants were required to categorize, were mimicked. Based on this, they concluded that emotional mimicry is not an automatic process but rather depends on an individual's current goals. While arousal was not measured and a between-subjects design was used, the findings remain robust. These studies suggest that regardless of the task used or the cognitive function examined, emotions influence behavioral responses only when they are task-relevant.

### 1.1. *Purpose of the current systematic review*

This systematic review seeks to evaluate whether existing literature supports the hypothesis that goal-relevance plays a pivotal role in shaping emotional stimulus processing and directing behavioral responses. According to the motivational model, highly arousing stimuli are thought to trigger automatic responses aligned with their valence (Bradley et al., 2001; Lang and Bradley, 2010). However, if emotional stimuli are instead evaluated based on their relevance to the individual's current goals, they may be selectively filtered out when deemed irrelevant. These competing predictions can be tested by comparing empirical findings on emotional stimuli that are task-relevant versus task-irrelevant. If such stimuli cannot be filtered or appraised according to goal-relevance, they should elicit similar responses regardless of task demands. To align with the aforementioned studies (Calbi et al., 2022; Mancini et al., 2020, 2022; Mirabella, 2018; Mirabella et al., 2024a; Mirabella et al., 2023; Mirabella et al., 2024b; Montalti and Mirabella, 2023, 2024), we selected studies specifically examining response readiness and inhibitory control, applying rigorous inclusion criteria to ensure methodological consistency and enable meaningful comparisons across findings.

First, we comprised studies exploiting either the Stop-signal task (SST; Logan et al., 1984) or the Go/No-go task (Donders, 1969). We decided to focus on these tasks because they assess two components of motor control i.e., motor inhibition, a core executive function (Bari and Robbins, 2013; Diamond, 2013; Mirabella, 2021) as well as motor readiness. As detailed in the following paragraphs, the SST evaluates the ability to suppress a preplanned action, while the Go/No-go task evaluates the ability to suppress a potential action or response readiness. We selected these tasks because, despite slight modifications depending on specific experimental questions, they maintain a well-defined design and relatively consistent behavioral outcomes. Additionally, given their widespread use among researchers, we were confident in obtaining a substantial number of articles.

Second, we selected only papers that recruited healthy young adults (i.e., 18–35 years) because of the ability to deal with emotional stimuli changes across the life span (Daley et al., 2020; Rutter et al., 2019). Thus, we restricted our selection to papers testing people in young adulthood because this phase is characterized by an almost stable biological and psychological maturation (Medicine and Council, 2015).

Third, we excluded studies where brain activity was affected using non-invasive stimulation techniques (i.e., transcranial magnetic stimulation, transcranial direct current stimulation) or exploiting mindfulness-based psychotherapy because, in both scenarios, the normal functioning of emotion processing is altered. However, we included data taken from healthy controls or placebo/sham groups when available.

Fourth, we selected studies that utilized visual facial expressions of real people and required participants to respond with motor actions using their hand or arm. Facial expressions were included due to their fundamental role in non-verbal social interactions (Crivelli and Fridlund, 2018; Jack and Schyns, 2015). Unlike other emotional stimuli, such as images from the International Affective Picture System (Lang, 2005), emotional facial expressions differ only in the conveyed emotion, minimizing variability in visual features. Additionally, we focused on studies where participants used their hand or arm, as the neural mechanisms controlling these effectors differ from those regulating gait and eye movements.

Finally, we excluded studies in which participants responded to internal triggers, as experimental control over such stimuli is limited. We also did not include studies that lacked behavioral data, since, without observable actions, the findings are more susceptible to speculative interpretations. Instead, behavioral measures allow us to compare different evidence directly.

Before proceeding, we will briefly summarize the key features of each selected task to clarify the aspects of motor and attentional control they assess and to outline the most relevant behavioral parameters used as outcome measures.

### 1.2. *Tasks*

#### 1.2.1. *The Stop-signal task*

The SST is conceived to measure the ability to suppress a prepotent motor response (Bari and Robbins, 2013; Logan, 1994; Verbruggen et al., 2019). It consists of a pseudorandom mix of two types of trials, i.e., the no-stop and stop trials (Fig. 1A). In its simplest version, during no-stop trials, a go-signal, e.g., the presentation on a computer screen of the letter 'O', indicates participants to press a key as quickly as possible. Instead, during the stop trials, after the presentation of the go-signal but before the movement onset (i.e., during the reaction time, RT), a stop-signal, e.g., the presentation of the letter 'X', is shown, instructing participants to suppress the pending movement. The delay between the go- and the stop-signal, the stop-signal delay (SSD), is of crucial importance because the longer the SSD, the more difficult it is to suppress the movement (Logan, 1994; Logan et al., 1984). Often, but not always, the length of the SSD is controlled by a staircase procedure (for more details see Verbruggen et al., 2019). The staircase increases the SSD by a prespecified amount of time, e.g., 50 ms, making stopping more difficult when participants correctly withheld the movement. Instead, when participants fail to inhibit, the SSD is decreased by the same time, making stopping easier. This way, the staircase allows successful stopping in 50 % of stop trials (Verbruggen et al., 2019). In the standard SST paradigms, the no-stop trials are more frequent than stop trials (e.g., 64 or 75 % *vs.* 34 or 25 %, respectively), to create a strong tendency to move (Verbruggen et al., 2019). This is important as people spontaneously tend to give more importance to stopping and postponing their response to facilitate inhibition (Logan, 1994). Furthermore, to discourage this waiting strategy, researchers usually verbally remark that stop and no-stop trials are equally important and set a maximum time for responding in no-stop trials (Verbruggen et al., 2019).

Notably, motor inhibition is not a unitary construct but has at least two neuropsychological domains: (1) reactive inhibition, i.e., the ability to react to the presentation of a stop-signal, and (2) proactive inhibition, i.e., the ability to modulate reactive inhibition preemptively according to one's goal (Mirabella, 2023; van den Wildenberg et al., 2022). In most papers, authors measure only the reactive component, which is assessed by computing the stop-signal reaction time (SSRT), a covert RT, estimated via the horse-race model (Logan et al., 1984; Verbruggen et al., 2019). The shorter the SSRT, the better reactive inhibition, and vice versa. Assessing proactive control is more controversial (Mirabella, 2021, 2023; van den Wildenberg et al., 2022), and, as briefly discussed later, among the selected articles, it was measured just one time (Jia et al., 2023).

In the emotional versions of the SST either the go-signal, the stop-signal, or both consist of emotional stimuli with different valences.

#### 1.2.2. *The Go/No-go task*

The Go/No-go task (Donders, 1969) evaluates a different aspect of motor inhibitory control compared to the SST, focusing on the ability to prevent a potential action rather than suppressing an ongoing one. However, as we will discuss later, in certain cases, it can also be used to evaluate motor readiness in situations where participants are aware that they may need to withhold movement at times (e.g., Mancini et al., 2020;

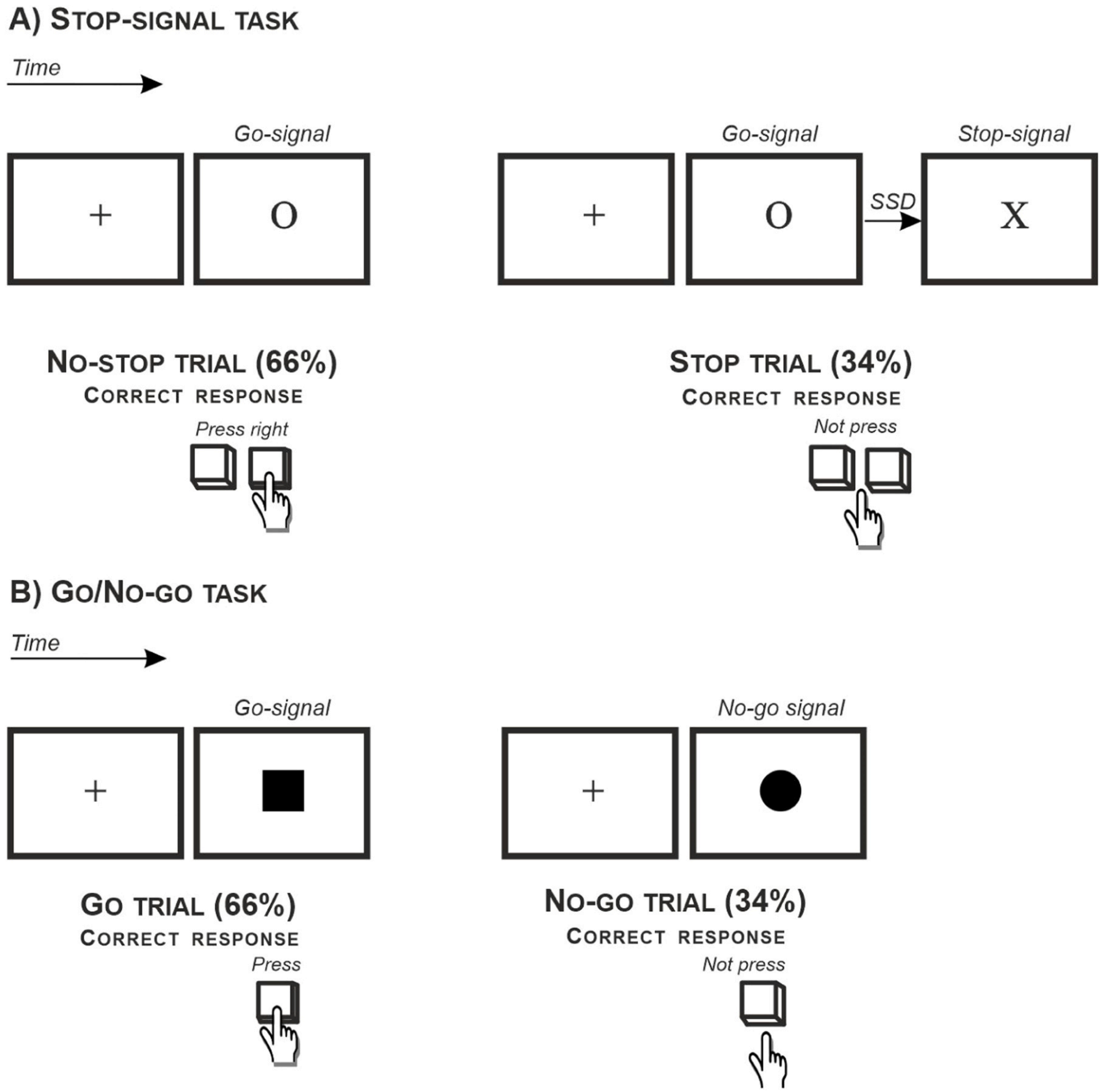


**Fig. 1.** Schematics of the tasks. Both tasks are illustrated in their most straightforward implementation. A) Stop-signal task. Most of the time (e.g., 66 %), participants have to respond quickly and accurately when an 'O' letter (go-signal) is presented at the center of the screen by pressing a button (no-stop trials). However, randomly, in a small percentage of the trials (e.g., 34 %), the go-signal is followed by another letter (X, stop-signal), which indicates the participants to withhold the pending response (stop trial). Often, the time between the onset of the Go- and the stop-signal, named stop-signal delay (SSD), is dynamically adjusted based on the participant's performance. The staircase algorithm increases the SSD when she/he successfully inhibits her/his response, making stopping harder, while it decreases the SSD when she/he fails, making stopping simpler. B) The Go/No-go task. Participants must respond quickly and accurately when a square (go-signal) is presented at the center of the screen by pressing a button (Go trials). In contrast, they are required to refrain from responding when a circle (No-go signal) is shown (No-go trials). The two types of trials are randomly intermixed, and Go trials often have a higher frequency than No-go trials (e.g., 66 vs 34 %).

Mirabella, 2018; Mirabella et al., 2023; Mirabella et al., 2024b; Montalti and Mirabella, 2023, 2024). It consists of a pseudorandom mix of go- and no-go trials (Fig. 1B). In go-trials, at delays, after trials start, a go-signal consisting of a visual stimulus (e.g., a square) is shown on a computer monitor, and participants have to press a key. On no-go trials, a different visual stimulus, e.g., a circle (no-go signal), is shown, and participants have to refrain from moving. So, unlike the stop trials in the SST, during no-go trials, the go-signal doesn't precede the no-go signal; instead, it's displayed instead of it. As it was for the SST, in this paradigm, the rate of go-trials is usually higher than that of the no-go trials to induce a prepotent tendency to respond (Wessel, 2018; Young et al., 2018).

Although variants of the Go/No-go task can be used to measure proactive inhibition, all the papers focus solely on the reactive component by assessing the rate at which participants perform a movement despite the presence of a no-go signal (commission errors). Instead, motor readiness is indexed by the length of the RT or by the frequency at which participants do not respond to go-signals (omission errors).

In the emotional versions, the go-signal, the no-go signal, or both consist of emotional stimuli with different valences.

## 2. Methods

This review follows the guidelines in the PRISMA statement (Liberati et al., 2009; Page et al., 2021). We tracked and documented each stage of the screening process using a structured Excel spreadsheet (see https://osf.io/szg4m/).

### 2.1. Eligibility criteria

This review focuses on how healthy young adults react to real emotional facial expressions by moving the arm or the hand in the two above-described tasks when their brain activity is not undergoing invasive or non-invasive stimulation or mindfulness-based interventions. The authors established the eligibility criteria a priori, and doubts in the selection processes were discussed and resolved by consensus. To be included in this review, studies had to meet the following criteria:

a) employ validated pictures of real static faces depicting at least two facial expressions, neutral and/or one or more of the six basic emotions (i.e., sadness, happiness, fear, anger, surprise, and disgust; Ekman and Friesen, 1971). Studies employing non-validated stimuli, such as pictures taken from the internet, personal collections, or photographs of laboratory members, were excluded. Similarly, studies using schematic, morphed, or computer-generated faces were excluded since these stimuli differ from real faces in their capacity to convey emotions (Blagrove and Watson, 2014; Kendall et al., 2016).
b) have participants between 18 and 35 years old and healthy. Studies involving patients, healthy children, and elderly individuals were excluded. This age range was chosen to ensure a homogeneous sample and to minimize the potential confounding effects of age-related changes in emotional processing. However, i) young adults from studies exploring healthy individuals across the lifespan and ii) the healthy control groups from studies involving patients were included
c) ensure experimental groups consisting of more than 15 individuals, as smaller groups are more susceptible to significant inter-subject variability, which can impact the reliability of the results;
d) entail behavioral measures (SSRT, RT, omission, and commission errors) associated with emotional stimuli, and their statistical analyses. We excluded studies that focused solely on signal detection theory;
e) employ the hand or arm as effectors. Studies exploiting the eyes or the lower limbs were excluded, as the neural control of these effectors differs from that of the arm and hand;
f) not exploiting brain stimulation techniques (e.g., transcranial magnetic stimulation or transcranial direct current stimulation) or treatments altering brain functioning (e.g., hypnosis, mindfulness, sleep deprivation, hormones, drugs). This exclusion was made to maintain the focus on the natural processing of emotions without any external influences. However, data from control groups (e.g., placebo or sham) when available, were included;
g) being written in English language and published in international peer-reviewed journals. Conference papers, systematic reviews, and meta-analyses were excluded.

### 2.2. Search strategy

Systematic literature searches were conducted on May 31st, 2024, using PubMed (pubmed.ncbi.nlm.nih.gov/) and Scopus (www.scopus.com/), without imposing publication date restrictions, but limited to articles published in English language. We performed four searches for the SST using the following strings: i) [*emoti* AND face** AND *'stop signal'*]; ii) [*emoti* AND face** AND '*countermanding*']; iii) [*emoti* AND facial* AND *'stop signal'*]; and iv) [*emoti* AND facial* AND '*countermanding*']. For the Go/No-go task, we performed six searches using the following strings: i) [*emoti* AND face** AND *'go no go'*]; ii) [*emoti* AND face** AND '*go nogo*']; iii) [*emoti* AND face** AND '*gonogo*']; iv) [*emoti* AND facial* AND *' go no go'*]; v) [*emoti* AND facial* AND '*go nogo*']; and vi) [*emoti* AND facial* AND '*gonogo*']. The keywords had to appear in the title or abstract.

### 2.3. Study selection

The two authors independently reviewed each unique search result to ascertain its eligibility. Instances of disagreement regarding article eligibility were infrequent, occurring in only 4 % of cases, and were resolved through discussion between the authors.

### 2.4. Quality appraisal

All selected papers were observational, analytical, and cross-sectional studies. Thus, the two authors independently evaluated the methodological approach's strengths and weaknesses and examined how effectively biases were addressed using the Joanna Briggs Institute Critical Appraisal Tools for Analytical Cross-Sectional Studies (Moola et al., 2020). This scoring system is based on eight criteria, specifically focusing only on the methodological aspects such as how the sample was selected, whether the variables of interest were measured in a reliable way, how statistical analyses were conducted, etc. (see Table S1 in Supplementary Material for the complete list of assessment items). For each criterion, the assessor could assign a score ranging from 0 to 2 in increments of 0.5, or indicate that it was not applicable (N/A). If a criterion was deemed not applicable, it was excluded from the overall score of the paper. The scores of each criterion were summed and divided by the highest possible score, i.e., 16 if all criteria were applicable. Studies achieving a score $> 80$ % were rated as high quality and not biased, those within a score range of 66–80 % were rated as satisfactory quality and not heavily biased, and those in the range of 51–65 % were rated as medium-low quality and with biases. Finally, studies with a score $\leq 50$ % were discarded. In the Supplementary Materials, we also report the full operational definitions for each scoring criterion.

### 2.5. Data extraction and synthesis of results

Information extracted from the chosen studies was collected using two structured proformas: one for extracting data from the Stop-signal task, with entries corresponding to those in Table 3, and another for the Go/no-Go task, with entries matching those in Table 4. These proformas documented various aspects, including sample features (e.g., sample size, gender distribution, and age demographics), specifics of the study design (e.g., task descriptions, stimuli employed, and arousal assessment), as well as key findings about the impact of emotional stimuli on behavioral outcomes (e.g., SSRT, RT, commission, and omission errors). The datasets used to produce the figures and summaries are available as .xlsx spreadsheets at https://osf.io/szg4m/.

## 3. Results

### 3.1. Search results

Because of the stringent criteria for inclusion and exclusion, 52 articles met the requirements for this review, encompassing the two tasks.

#### 3.1.1. Search results for the SST

The search for SST generated 130 articles, which were subsequently reduced to 54 following the elimination of duplicates. Upon screening titles and abstracts based on predefined inclusion/exclusion criteria, 45 articles remained. Subsequently, the full texts of these articles were examined to determine adherence to eligibility criteria, resulting in a final selection of 18 articles (Fig. 2).

#### 3.1.2. Search results for the Go/No-go task

The initial search for the Go/No-go task produced 913 articles. After removing duplicates, 255 articles remained. Screening the titles and abstracts further narrowed this down to 172 articles, and a full-text examination ultimately left 34 articles (Fig. 3).

### 3.2. Methodological quality assessment

The results of the quality assessment of the SST's articles ($n = 18$) are shown in Table 1; those for Go/No-go articles ($n = 34$) are presented in

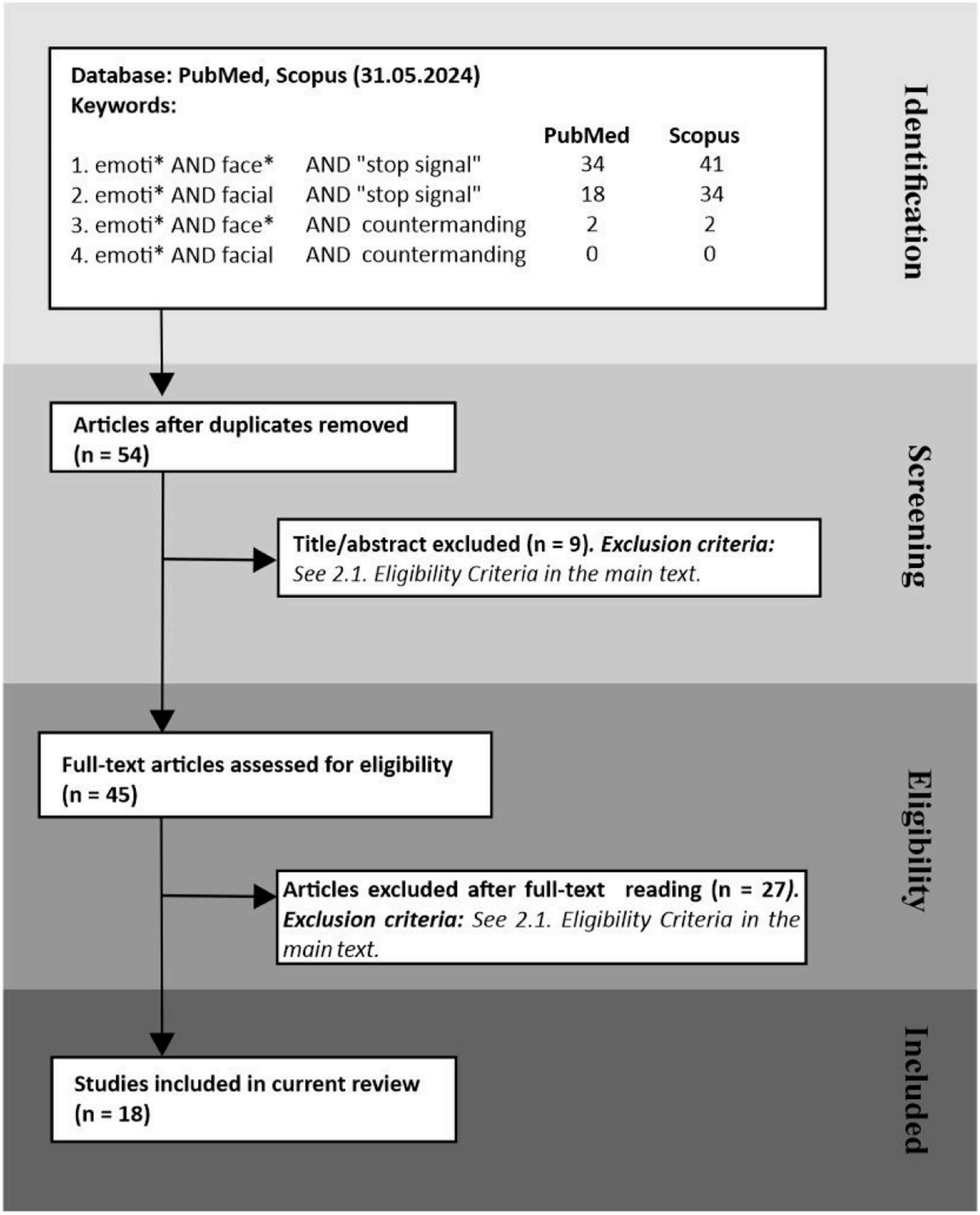


**Fig. 2.** Flow charts of the four searches on the emotional Stop-signal task using PubMed and Scopus conducted on May 31st, 2024. The keywords had to be found in the titles or abstracts, and the language was limited to English, but there was no limitation on publication dates. We first analyzed titles and abstracts and then the full texts, and we excluded studies according to the eligibility criteria detailed in paragraph 2.1. Eighteen articles satisfied the requirements.

Table 2. The two reviewers agreed on 46 of the 52 articles (~88.5 %), and after further discussion, they reached a consensus on all the articles. Inter-rater agreement was assessed using Cohen's kappa (Cohen, 1960), calculated separately for each question and presented in the final row of Tables 1 and 2 (the individual evaluations from each reviewer in .xlsx format, are available at: https://osf.io/szg4m/). Detailed evaluations for each author are provided in the Supplementary Materials. Regarding the SST studies, three papers were excluded due to low-quality scores (see Supplementary Material for details). Of the remaining 15 studies, seven were rated as high satisfactory quality (~46.7 %), and eight as medium-low quality (~53.3 %). As for the Go/No-go studies, seven papers were excluded because of low-quality scores (see Supplementary Material for details). Of the remaining 27 studies, five were rated as high quality (~18.5 %), 3 as satisfactory quality (~11.1 %), and 12 as medium-low quality (~70.4 %).

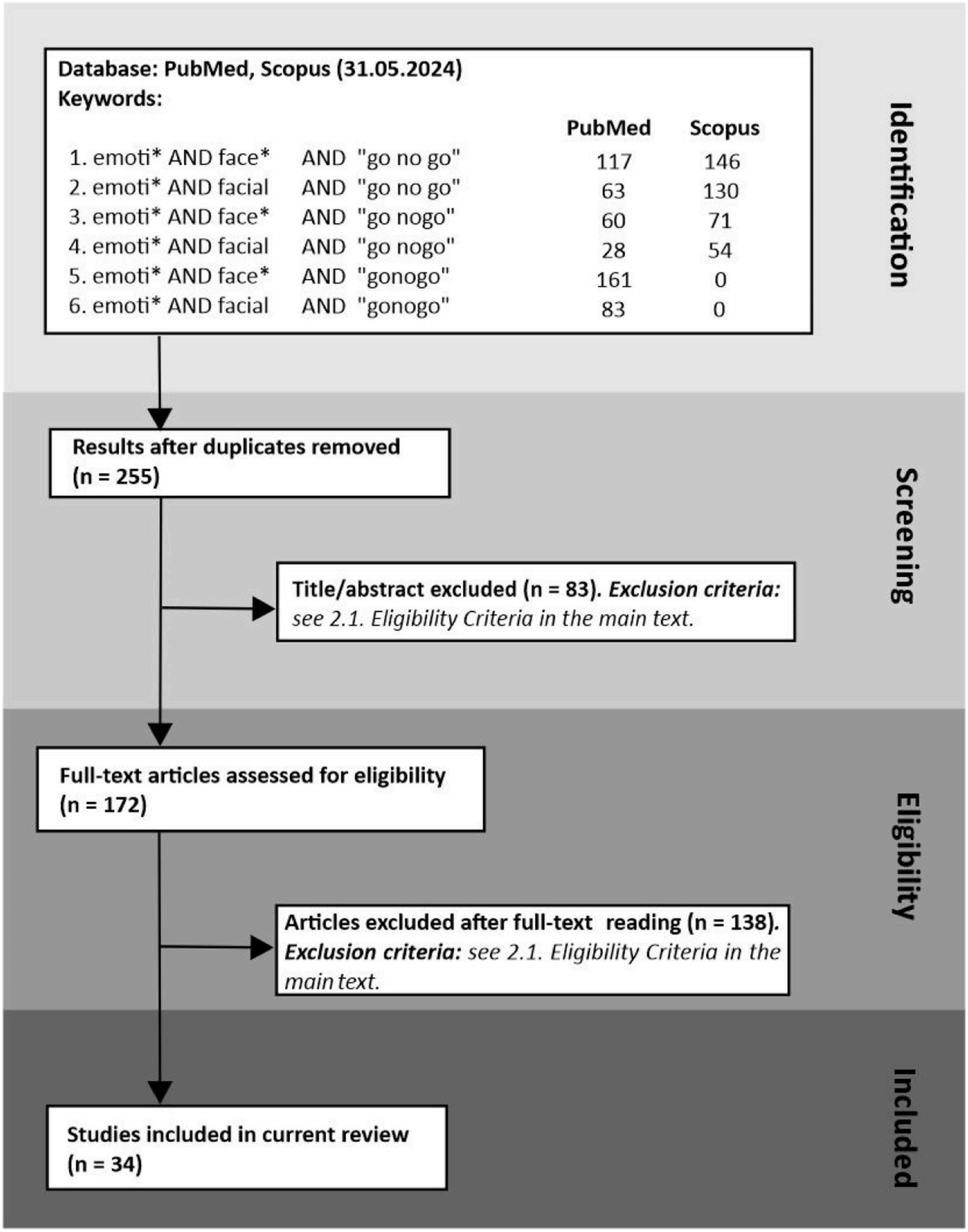


**Fig. 3.** Flow charts of the six searches on the emotional Go/No-go task using PubMed and Scopus conducted on May 31st, 2024. The keywords needed to be present in the titles or abstracts, and only articles in English were considered, with no restrictions on publication dates. We first analyzed the titles and abstracts, followed by the full texts, excluding studies based on the eligibility criteria outlined in paragraph 2.1. Ultimately, 34 articles met the requirements.

### *3.3. Main outcomes of selected studies*

In this paragraph, we will individually summarize the key findings from the selected studies (n = 42) for each task (n = 15 for the SST and n = 27 for the Go/No-go task), emphasizing elements of the experimental design that could introduce bias. We will examine whether emotional stimuli were utilized as go-signals, stop-signals, or both, their relevance to the task, and whether arousal levels were assessed

#### *3.3.1. Outcomes of studies using the Stop-signal task*

We first examined whether emotional expressions were used as go-signals, stop-signals, or both. This distinction is important because if emotional expressions serve as go-signals in no-stop trials, the experimenters intend to influence the speed of the go-process and observe if this change impacts the stop-process. Conversely, if emotional expressions function as stop-signals, presented only in stop-trials, the aim is to determine whether they directly affect the stop-process. When emotional

**Table 1**
Summary of the quality assessment of Stop-signal task's studies.

| Articles | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Percentage | Outcome |
|---|---|---|---|---|---|---|---|---|---|---|
| Battaglia et al. (2022) | 2 | 2 | 2 | N/A | N/A | N/A | 0 | 1 | 70 | Included |
| Ding et al. (2020) | 2 | 1.5 | 2 | N/A | N/A | N/A | 0 | 2 | 75 | Included |
| Gupta and Singh (2021) | 2 | 1 | 1.5 | N/A | N/A | N/A | 0 | 1 | 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 |
| Liang et al. (2022) | 2 | 2 | 2 | N/A | N/A | N/A | 0 | 0 | 60 | Included |
| Lodha and Gupta (2024) | 2 | 1 | 2 | N/A | N/A | N/A | 0 | 2 | 70 | Included |
| Pandey and Gupta (2022a) | 2 | 1 | 2 | N/A | N/A | N/A | 0 | 2 | 70 | Included |
| Pandey and Gupta (2022b) | 2 | 1 | 1.5 | N/A | N/A | N/A | 0 | 1.5 | 60 | Included |
| Pawliczek et al. (2013) | 2 | 1.5 | 1 | N/A | N/A | N/A | 0.5 | 1 | 60 | Included |
| Pessoa et al. (2012) | 2 | 0.5 | 2 | 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 |
| Schag et al. (2023) | 2 | 2 | 2 | N/A | N/A | N/A | 0 | 1 | 70 | Included |
| Song et al. (2016) | 2 | 1.5 | 2 | N/A | N/A | N/A | 0 | 1 | 65 | Included |
| Stockdale et al. (2015) | 2 | 1 | 0 | N/A | N/A | N/A | 0 | 2 | 50 | Excluded |
| Stockdale et al. (2017) | 1 | 2 | 0 | 2 | 0 | 0 | 0 | 2 | 50 | Excluded |
| Stockdale et al. (2020) | 2 | 1 | 0 | N/A | N/A | N/A | 0 | 2 | 50 | Excluded |
| Williams et al. (2020) | 2 | 2 | 2 | N/A | N/A | N/A | 0.5 | 1.5 | 80 | Included |
| *Cohens'k* | *1* | *.80* | *.60* | *1* | *1* | *1* | *.68* | *.80* | | |

*Notes.* For each study, we reported the final evaluation for each question of the selected assessment tool. In this tool, 2="yes", 1="unclear", 0="no", and N/A means "Not Applicable". Cohens'k indicated the inter-rater agreement for each question. See the main text for more information.

**Table 2**
Summary of the quality assessment of the Go/No-go task's studies.

| Articles | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Percentage | Outcome |
|---|---|---|---|---|---|---|---|---|---|---|
| Carvalho Fernando et al. (2013) | 2 | 1.5 | 1 | N/A | N/A | N/A | 1 | 1 | 65 | Included |
| Cecere et al. (2013) | 1 | 1 | 1 | N/A | N/A | N/A | 1 | 0 | 40 | Excluded |
| Liu et al. (2021) | 2 | 1 | 1 | N/A | N/A | N/A | 1 | 2 | 70 | Included |
| Ly et al. (2014) | 2 | 0.5 | 1 | N/A | N/A | N/A | 1 | 0 | 45 | Excluded |
| Ma et al. (2013) | 2 | 1.5 | 0 | N/A | N/A | N/A | 1 | 1.5 | 60 | Included |
| Mancini et al. (2020) | 2 | 0.5 | 2 | N/A | N/A | N/A | 2 | 2 | 85 | Included |
| Mancini et al. (2022) | 2 | 1 | 2 | N/A | N/A | N/A | 2 | 2 | 90 | Included |
| Maxwell et al. (2005) | 2 | 0.5 | 2 | N/A | N/A | N/A | 1 | 0.5 | 60 | Included |
| Mirabella (2018) | 2 | 0.5 | 2 | N/A | N/A | N/A | 2 | 2 | 85 | Included |
| Montalti and Mirabella (2023) | 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 |
| Pacheco-Unguetti et al. (2012) | 1 | 0.5 | 2 | 2 | 1 | 1 | 1 | 0.5 | 56.2 | Included |
| Parkinson et al. (2017) | 1 | 0.5 | 2 | N/A | N/A | N/A | 1 | 1.5 | 60 | Included |
| Pornpattananangkul et al. (2015) | 2 | 0.5 | 2 | N/A | N/A | N/A | 1 | 2 | 75 | Included |
| Putman et al. (2010) | 1 | 0.5 | 1 | N/A | N/A | N/A | 1 | 2 | 55 | Included |
| Quaglia et al. (2016) | 2 | 1.5 | 0 | N/A | N/A | N/A | 1 | 1 | 55 | Included |
| Quaglia et al. (2019) | 2 | 1 | 0.5 | N/A | N/A | N/A | 1 | 1 | 55 | Included |
| Schlosser et al. (2013) | 2 | 2 | 0.5 | N/A | N/A | N/A | 1 | 1 | 65 | Included |
| Schulz et al. (2007) | 2 | 1.5 | 0.5 | N/A | N/A | N/A | 1 | 1 | 60 | Included |
| Schulz et al. (2009) | 2 | 1.5 | 0.5 | N/A | N/A | N/A | 1 | 1 | 60 | Included |
| Sinke et al. (2017) | 2 | 0.5 | 2 | N/A | N/A | N/A | 1 | 0.5 | 60 | Included |
| Soloff et al. (2017) | 2 | 0.5 | 0.5 | N/A | N/A | N/A | 1 | 0 | 40 | Excluded |
| Steffen et al. (2009) | 2 | 0.5 | 1 | N/A | N/A | N/A | 1 | 1 | 55 | Included |
| Tamietto et al. (2006) | 2 | 1.5 | 0.5 | N/A | N/A | N/A | 1 | 1 | 60 | Included |
| Taylor et al. (2018) | 2 | 0.5 | 0 | N/A | N/A | N/A | 1 | 0 | 35 | Excluded |
| Vandewouw et al. (2021) | 2 | 0.5 | 0 | N/A | N/A | N/A | 1 | 1 | 45 | Excluded |
| Windmann and Chmielewski (2008) | 1 | 1 | 1 | N/A | N/A | N/A | 1 | 0 | 40 | Excluded |
| Yang et al. (2014) | 2 | 0.5 | 0 | N/A | N/A | N/A | 2 | 0 | 45 | Excluded |
| Yeung et al. (2024) | 2 | 2 | 0.5 | N/A | N/A | N/A | 1 | 1 | 65 | Included |
| Yu et al. (2015) | 2 | 1.5 | 1 | N/A | N/A | N/A | 1 | 0 | 55 | Included |
| Zhang and Lu (2012) | 2 | 0.5 | 1 | N/A | N/A | N/A | 2 | 0 | 55 | Included |
| Zhang et al. (2016) | 2 | 0.5 | 1 | 2 | 1 | 1 | 2 | 0 | 59.4 | Included |
| Zhang et al. (2020) | 2 | 1 | 1.5 | N/A | N/A | N/A | 2 | 0 | 65 | Included |
| Zhu et al. (2024) | 2 | 0.5 | 1.5 | N/A | N/A | N/A | 1 | 2 | 70 | Included |
| *Cohens'k* | *0.74* | *.73* | *.82* | *1* | *.79* | *.79* | *.86* | *.84* | | |

*Notes.* For each study, we reported the final evaluation for each question of the selected assessment tool. In this tool, 2="yes", 1="unclear", 0="no", and N/A means "Not Applicable". Cohens'k indicated the inter-rater agreement for each question. See the main text for more information.

expressions serve as both go- and stop-signals, both go- and stop-processes are affected in complex ways, making the results challenging to interpret. For this reason, such a design is rarely used (see below).

Seven papers used emotional faces only as go-signals (see Table 3; Ding et al., 2020; Jia et al., 2023; Liang et al., 2022; Pawliczek et al., 2013; Rebetez et al., 2015; Schag et al., 2023; Song et al., 2016). In addition, Lodha and Gupta (2024) exploited facial emotional expressions as prime. As the prime stimuli preceded the go-signal, presumably influencing the go process, we included this paper in the corresponding category of papers. Out of these studies, in four articles, the emotional valence of faces was irrelevant to the task because participants were instructed to respond by pressing a key either to the posers' gender (Rebetez et al., 2015; Schag et al., 2023) or to the color of the frame surrounding the face image (Pawliczek et al., 2013) or the images were used as primes (Lodha and Gupta, 2024). In three studies, the emotional expressions were task-relevant, as participants had to respond via keypresses according to the valence of the expressions (Ding et al., 2020; Jia et al., 2023; Song et al., 2016). Additionally, one study employed a within-subjects design to compare task-relevant and task-irrelevant emotional faces (Liang et al., 2022). Finally, only one paper, by Pandey and Gupta (2022a), used emotional expressions as both go- and stop-signals, with the valence of faces being irrelevant, as participants responded based on the poser's gender.

To summarize the results concisely, we combined all negative-valence emotions (sad, fear and angry faces) and compared their effect on the SSRT with happy faces, the only positive expression used, and neutral faces (Fig. 4A). The findings are straightforward. When facial expressions served as go-signals and were relevant to the task, negative-valence faces impaired reactive inhibition by slowing the SSRT (Ding et al., 2020; Jia et al., 2023; Liang et al., 2022; Song et al., 2016). However, when these expressions were task-irrelevant (Liang et al., 2022; Lodha and Gupta, 2024; Pawliczek et al., 2013; Rebetez et al., 2015; Schag et al., 2023), no consistent pattern emerged and in three out of nine or 33 % of cases, these stimuli produced no effect at all. This conclusion is further supported by the fact that the only study using a within-subjects approach, and thus, controlling or intraindividual variability (Liang et al., 2022), showed that images' valence only has an effect when task-relevant.

When emotional faces were used as stop-signals they were always task-irrelevant in all studies (see Table 3, Battaglia et al., 2022; Gupta and Singh, 2021; Gupta and Singh, 2023; Pandey and Gupta, 2022b; Pessoa et al., 2012) except that in Williams et al. (2020), who studied the effect of task-relevant *vs*. task-irrelevant emotional faces on stop-signal using a between-subject design. Some of these papers provided more than one outcome. Pandey and Gupta (2022b) gave two hits because they compared the effect of facial emotions in two conditions, i.e., high *vs*. low attentional load, using a within-subject design. Williams et al. (2020) gave three hits because they studied the effect of task-relevant *vs*. task-irrelevant emotional faces on stop-signal using a between-subject design. As shown in Fig. 4B, when task-irrelevant, most times (14 out of 22 or 56 %), emotional faces do not affect reactive inhibition. In the other instances, no clear patterns emerge. The paper by Williams et al. (2020) supports this claim, as in both experiments in which emotional expressions were not relevant, the SSRT was not affected by the images' valence. However, when participants had to inhibit their response as a function of the emotional expression, negative faces (fearful expressions) impaired reactive inhibition, increasing the SSRT (Williams et al., 2020). This result aligns with those obtained when emotions are on the go-signal and are task-relevant.

As expected, the results of Pandey and Gupta (2022a) are more complex (see Fig. 4C). The authors found that facial expression valence influenced reactive inhibition only when the go-signal was a neutral face. In this condition, negative faces used as stop-signals resulted in longer SSRT compared to neutral and positive faces, which did not differ from each other. In contrast, when the go-signal was an emotional face (both negative and positive), reactive inhibitory control was unaffected by the valence of the stop-signal face. Since three facial expressions were used as go-signals and another three as stop-signals, there were nine possible combinations, resulting in nine data points for this study.

By combining all study conditions, we found that when facial emotional expressions were irrelevant to the task, stimulus valence did not influence behavioral responses in 25 out of 40 or 62.5 % of cases while no clear pattern was observed in the remaining instances (Fig. 4D). Conversely, when the emotional content was task-relevant, valence did not affect behavioral responses just one out of seven times (14.3 %). In the remaining cases, negative facial expressions impaired

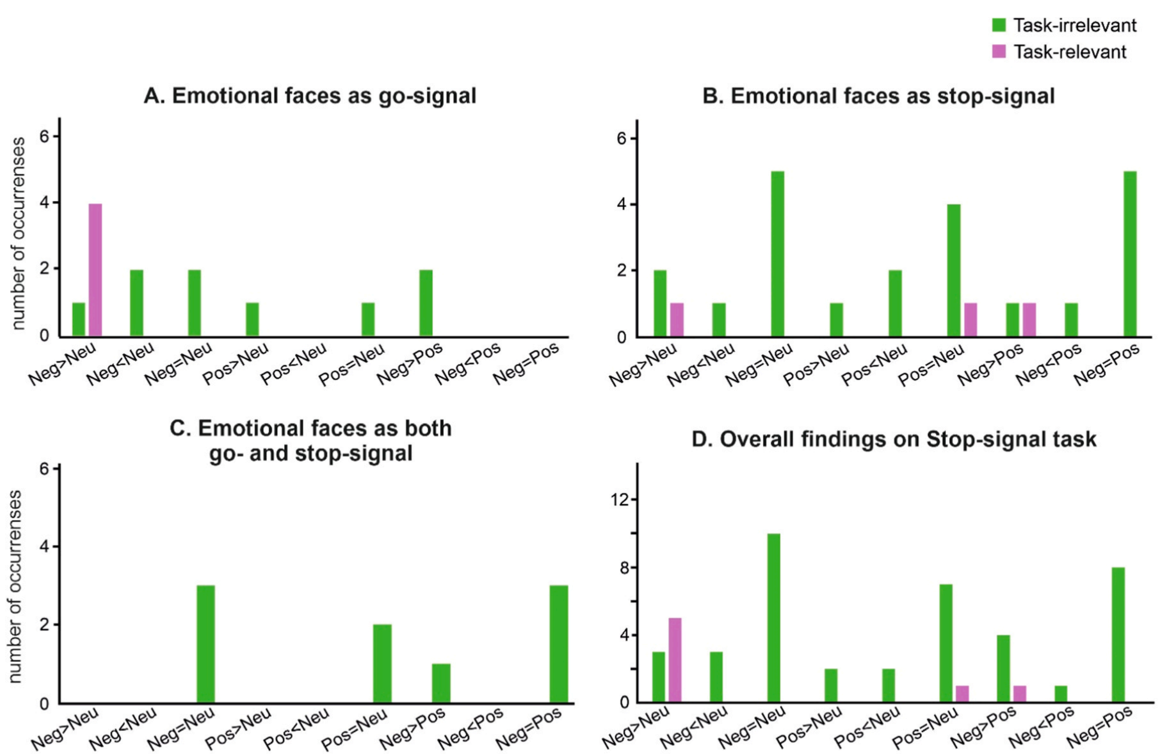


**Fig. 4. Summary of Stop-signal task studies' results.** The bar plots represent the absolute frequency of each possible outcome related to the length of the stop signal reaction time (SSRT). For instance, "Neg>Neu" indicates that negatively valenced faces resulted in longer SSRTs than neutral ones. In all cases, outcomes were categorized based on statistical significance, specifically when the comparison between emotional stimuli of different valences yielded a p-value< 0.05. The data is categorized based on the relevance of emotional stimuli in the task: task-irrelevant (green) and task-relevant (lilac). Panel (A) displays occurrences from studies where emotional faces were used solely as go-signals; panel (B) shows occurrences from studies where they were used only as stop-signals; panel (C) presents occurrences from studies where emotional faces functioned as both go- and stop-signals; and panel (D) provides the overall occurrences across all conditions. Abbreviations: Negative valence images (Neg); Neutral valence images (Neu); Positive valence images (Pos).

reactive inhibition in six out of seven instances (85.8 %), leading to longer SSRTs compared to neutral faces in five out of seven instances (71.5 %) and compared to positive faces in one out of seven instances (14.3 %). Although this result appears consistent, it is essential to highlight that the number of studies in the task-relevant category is low (n = 5).

These findings should be viewed with caution due to the presence of several uncontrolled experimental confounders. The most significant issue is the evaluation of the images' arousal. Although it is well-established that this dimension of emotional stimuli affects behavioral responses (Bradley et al., 2001; Lang and Bradley, 2010; Lundqvist et al., 2014), nine out of 15 studies (60 %) did not assess it (Table 3). The remaining six articles did measure arousal (Table 3). However, although the emotional expressions in the experiment varied in arousal levels, this factor was never accounted for in the statistical analyses. Consequently, it remains possible that arousal, valence, or their interaction is the primary factor influencing behavioral responses.

Additional key challenges affecting the interpretation of the results stem from experimental design and data analyses. In eight papers, the number of stop-trials per experimental condition was fewer than 50 (average 26.5 ± 10.9, range 16–45; Battaglia et al., 2022; Gupta and Singh, 2021; Gupta and Singh, 2023; Jia et al., 2023; Liang et al., 2022; Lodha and Gupta, 2024; Pandey and Gupta, 2022a; Rebetez et al., 2015). Under these conditions, SSRT estimates are known to have low reliability (Verbruggen et al., 2019). In 11 studies (Ding et al., 2020; Gupta and Singh, 2021; Gupta and Singh, 2023; Liang et al., 2022; Pandey and Gupta, 2022a, b; Pawliczek et al., 2013; Pessoa et al., 2012; Rebetez et al., 2015; Schag et al., 2023; Song et al., 2016) SSRT were estimated using methods other than the integration method, which is considered less biased and more reliable when tracking procedures are applied (Verbruggen et al., 2019). Notably, in seven studies (Ding et al., 2020; Gupta and Singh, 2021, 2023; Jia et al., 2023; Lodha and Gupta, 2024; Pandey and Gupta, 2022b; Song et al., 2016)), the fundamental assumption of the horse-race model, i.e., the independence between stop- and go-processes (Logan et al., 1984; Verbruggen et al., 2019) was not assessed.

This assumption is tested by comparing the RT of stop-failure trials with those of no-stop trials, and the expected result is that the former should be significantly shorter than the latter. If this assumption is not met, the estimated value of the SSRT becomes questionable. Lastly, eight studies (i.e., 53.3 %; Battaglia et al., 2022; Gupta and Singh, 2021; Gupta and Singh, 2023; Liang et al., 2022; Pawliczek et al., 2013; Pessoa et al., 2012; Rebetez et al., 2015; Schag et al., 2023) did not provide the effect sizes for post-hoc comparisons (see Supplementary Material), raising concerns about the strength of the observed effects (Sullivan and Feinn, 2012). In summary, all 15 articles exhibit significant weaknesses in the interpretability of data concerning the measurement of reactive inhibition.

Proactive inhibition was evaluated only by Jia et al. (2023), who investigated the effect of emotional expressions on proactive inhibition by comparing the RT of two types of no-stop trials presented in separate blocks. In one block, participants knew that the go-signals were never followed by a stop-signal (certain no-stop trials). In the other block, the go-signals could be followed by a stop-signal 25 % of the time (uncertain no-stop trials). First, as expected, regardless of the valence of the emotional face, the RT of uncertain-go trials were slower than those of certain-go trials (Mirabella et al., 2008, 2006). Second, the difference in RT between the uncertain- and certain-go trials was larger when the go-signal was angry than neutral expression, suggesting that the former emotional stimulus improves proactive inhibitory control. Due to the limited empirical data on this aspect of motor inhibition, the only reasonable conclusion is that further research is necessary Table 3.

### 3.3.2. *Outcomes of studies using the Go/No-go task*

Using the same approach as for the SST, we categorized the studies involving the Go/No-go task based on whether emotional expressions were used as go-signals, no-go signals, or both. When emotional expressions are used as go- or no-go signals, they allow researchers to specifically assess their influence on the go and no-go processes, respectively. In contrast, when emotional expressions serve as both go- and no-go signals, or are used as primes or background images, they simultaneously impact both the go and no-go processes.

Out of the 27 studies included, only in seven instances emotional expressions were selectively used as go-signals (n = 4; Fig. 5A and B; Mancini et al., 2020; Mirabella, 2018; Montalti and Mirabella, 2023; Montalti and Mirabella, 2024) or no-go signals (n = 3; Fig. 5C; Mancini et al., 2022; Pornpattananangkul et al., 2015; Zhu et al., 2024). In all these studies, the emotional expressions were relevant to the task, as participants had to respond based on the presence of an emotional face, regardless of its valence. When emotional expressions served as go-signals and were task-relevant (Mancini et al., 2020; Mirabella, 2018; Montalti and Mirabella, 2023, 2024) RT were longer, and the rate of omission errors was higher for negative than positive faces[1] (Figs. 5A and 5B). In contrast, when emotional faces were used exclusively as no-go signals and were task-relevant, the three studies yielded different results (Fig. 5C). Mancini et al. (2022) found that negative faces enhanced inhibitory control, as the rate of commission errors elicited by negative expressions was lower than that elicited by positive ones. In contrast, Pornpattananangkul et al. (2015) observed the opposite effect, while Zhu et al. (2024) found no difference in commission error rates between positive and negative faces. Five of the previously mentioned studies utilized a within-subjects design to examine the effect of emotional faces when they were either task-relevant or task-irrelevant within the same group of participants (Mancini et al., 2020, 2022; Mirabella, 2018; Montalti and Mirabella, 2023, 2024). In the task-irrelevant condition, participants had to respond based on the posers' facial expressions. In these tasks, emotional expressions served as go- and no-go signals; therefore, the results will be discussed in the following paragraph.

In 20 studies, emotional facial pictures were presented as go- and no-go signals (Figs. 5D, 5E and 5F). In 12 studies emotional expressions were task-relevant (Carvalho Fernando et al., 2013; Ma et al., 2013; Putman et al., 2010; Quaglia et al., 2016, 2019; Schlosser et al., 2013; Schulz et al., 2009, 2007; Tamietto et al., 2006; Yu et al., 2015; Zhang et al., 2016). All these studies exploited the experimental design of Hare et al. (2005). In this design, participants had to move in response to one emotional facial expression (e.g., fear), and refrain from moving for a different emotional expression (e.g., happy) in one block of trials, and vice versa in another block. The effect of these emotions on behavior is compared across blocks. However, this design requires participants to execute distinct responses based on the stimulus valence. In our example, in one block, participants had to move when presented with fearful faces, and refrain from moving for happy faces, while the opposite instructions were applied in the next block. Consequently, emotional faces were associated with different motor responses within each block. This design choice complicates the comparison of the impact of emotional expressions on the same movement, as it can only be assessed across different blocks. This raises the risk of confusing the modulation of action readiness/inhibition with task instructions. In contrast, Mirabella's design examined the impact of task relevance without explicitly requiring participants to categorize different emotional expressions, as participants were instructed to respond whenever a face displayed any emotion, ensuring that both positive and negative emotional expressions were linked to the same motor response

[1] In one study (Montalti and Mirabella, 2024) the difference in omission error rates between negative and positive faces did not achieve statistical significance, although a trend in that direction was observed. Furthermore, in Mancini et al. (2020), only angry faces, and not fearful ones, triggered a significantly higher rate of omission errors compared to positive faces. These exceptions will be addressed in the Discussion section.

**Table 3**
Features and key findings of Stop-signal task studies.

| | Number and sex of participants | Mean Age ± SD [range] (years) | Task's features | Task-Relevance of emotional stimuli | Number of Trials | Stop-signal frequency | Face Emotions (database/s) | Arousal assessment | Outcome: change of SSRT |
|---|---|---|---|---|---|---|---|---|---|
| **Articles where emotional faces were used as Go signals** | | | | | | | | | |
| Ding et al. (2020) | 20 (all F) | 21.2 ± 1.7 | Go: Emotion discrimination<br>Stop-signal: Red cross over the face | **Relevant** | 480 | 25 % | S, Neu (CFAPS) | Yes° (S > Neu) | Neg > Neu |
| Jia et al. (2023) | 28 (14 F) | 22.3 ± 2.6 | Go: Emotion discrimination<br>Stop-signal: Change of color frame | **Relevant** | 480 | 25 % | A, Neu (KDEF) | No | Neg > Neu |
| Liang et al. (2022)* | 39 (24 F) | 19.9 ± 1.3 | Go: Emotion discrimination<br>Stop-signal: Stop symbol | **Relevant** | 240 | 25 % | S, Neu (CAPS) | No | Neg > Neu |
| Song et al. (2016) | 83 (47 F) | 21.4 ± 2.2 [18–25] | Go: Emotion discrimination<br>Stop-signal: Red cross over the face | **Relevant** | 480 | 25 % | S, Neu (CAPS) | Yes°° (S > Neu) | Neg > Neu |
| Liang et al. (2022)* | 39 (24 F) | 19.9 ± 1.3 | Go: Gender discrimination<br>Stop-signal: Stop symbol | Irrelevant | 240 | 25 % | S, Neu (CAPS) | No | Neg = Neu |
| Pawliczek et al. (2013) | 16 (all M) | 22.4 ± 2.3 | Go: Color of frame surrounding the face<br>Stop-signal: Change color frame | Irrelevant | 400 | 25 % | A, Neu (FEBA) | No | Neg < Neu |
| Rebetez et al. (2015) | 84 (55 F) | 22.8 ± 2.3 [18–30] | Go: Gender discrimination<br>Stop-signal: Auditory signal | Irrelevant | 384 | 25 % | H, A, Neu (KDEF) | No | Neg > Pos > Neu |
| Schag et al. (2023) | 20 (all F) | 36.5 ± 13.8 | Go: Emotion discrimination<br>Stop-signal: Change color frame | Irrelevant | 400 | 25 % | A, Neu (FEBA) | No | Neg < Neu |
| **Articles where emotional faces were used as primes** | | | | | | | | | |
| Lodha and Gupta (2024) | 34 (17 F) | 25.9 ± 5 | Go-signal: O/X Letter<br>Stop-signal: Green dot over the letter | Irrelevant | 192 | 25 % | H, A, Neu (KDEF and NimStim) | Yes°°°° (A=H)>Neu | Neg > Pos<br>Pos=Neu;<br>Neg=Neu |
| **Articles where emotional faces were used as Stop signals** | | | | | | | | | |
| Williams et al. (2020)* (Experiment 3) | 37 (22 F) | 19.22 ± 1.47 [18–26] | Go-signal: Circle/Square<br>Stop: Presentation of a face (emotion discrimination) | **Relevant** | 900 | 20 % | H, F, Neu (KDEF; PoFA; Ishai-NIMH set; NimStim) | No | Neg> (Pos=Neu) |
| Battaglia et al. (2022) | 30 (16 F) | 22.6 ± 3.6 | Go-signal: Left/Right Arrows<br>Stop-signal: Presentation of a face | Irrelevant | 512 | 25 % | F, Neu (POFA) | Yes°°° (F >Neu) | Neg<Neu |
| Gupta and Singh (2021) | 45 (12 F) | 26.0 ± 5.4 | Go-signal: O/X Letter<br>Stop-signal: Presentation of a face | Irrelevant | 192 | 25 % | H, A, Neu (KDEF and NimStim) | Yes° (H&A >Neu) | Neg< Pos;<br>Neg=Neu;<br>Neu=Pos |
| Gupta and Singh (2023) | 42 (27 F) | 27.5 ± 3.7 [20–37] | Go-signal: O/X Letter<br>Stop-signal: Presentation of a face | Irrelevant | 256 | 25 % | H, F, A, Neu (KDEF and NimStim) | Yes° (F=Neu)< (A=H) | (Neg=Pos)>Neu |
| Pandey and Gupta (2022b) (Experiment 2)* | 28 (3 F) | 23.20 ± 4.03 [18–30] | *Condition: Low attentional load*<br>Go-signal: Visual search with 2 letters Stop-signal: Presentation of a face | Irrelevant | 640 | 30 % | H, A, Neu (NimStim) | No | Neg=Pos=Neu |
| Pandey and Gupta (2022b) (Experiment 2)* | | | *Condition: High attentional load*<br>Go-signal: Visual search with many letters<br>Stop-signal: Presentation of a face | | | | | | *Neg>Pos;*<br>*Neu>Pos;*<br>*Neg=Neu* |
| Pessoa et al. (2012) (Experiment 1) | 32 (17 F) | [18–27] | Go-signal: Circle/Square<br>Stop-signal: Presentation of a face | Irrelevant | 900 | 20 % | H, F, Neu (KDEF; PoFA; Ishai-NIMH set; NimStim) | No | (Neg = Pos)<Neu |
| Williams et al. (2020)* (Experiment 1) | 40 (23 F) | 19.12 ± 1.68 [17–27] | Go-signal: Circle/Square<br>Stop-signal: Presentation of a face | Irrelevant | 900 | 20 % | H, F, Neu (KDEF; PoFA; Ishai-NIMH set; NimStim) | No | Neg =Pos = Neu |

(*continued on next page*)

Table 3 (*continued*)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Williams et al. (2020)* (Experiment 2) | 40 (22 F) | 18.70 ± 0.76 [17−20] | Go-signal: Circle/Square<br>Stop: Presentation of a face (gender discrimination) | Irrelevant | 900 | 20 % | H, F, Neu (KDEF; PoFA; Ishai-NIMH set; NimStim) | No | Neg =Pos = Neu |
| **Articles where emotional faces were used both as Go and Stop signals** | | | | | | | | | |
| Pandey and Gupta (2022a) | 56 (26 F) | 21.5 ± 3.9 [18−34] | *Condition: Go Neutral face*<br>Go: Gender discrimination<br>Stop-signal: Face appearing above the go-signal<br>*Condition: Go Negative face*<br>Go: Gender discrimination<br>Stop-signal: Face appearing above the go-signal<br>*Condition: Go Positive face*<br>Go: Gender discrimination<br>Stop-signal: Face appearing above the go-signal | Irrelevant | 1080 | 30 % | H, A, Neu (NimStim) | No | *only when the Go signal was Neu*<br>Neg> (Pos=Neu)<br><br>Neg=Pos=Neu<br><br>Neg=Pos=Neu |

*Notes*. The * indicates papers appearing more times for the following reasons: 1) Liang et al. (2022) exploited a within-subjects design comparing the effect of facial expressions on the go-signal when task-relevant and task-irrelevant; 2) Pandey and Gupta (2022b) exploited a within-subjects design comparing the effect of go-signal requiring low *vs.* high attentional resources; 3) Williams et al. (2020) exploited a between-subjects design comparing the effect of facial expressions on stop-signals when task-relevant and task-irrelevant (two experiments). In bold are indicated the papers where emotional expressions were task-relevant. ° The arousal was evaluated by a group of participants distinct from those involved in the main experiment; °° the arousal values were obtained from the original database scores; °°° the arousal was assessed by the same participants who participated in the experiment; °°°° it is unclear who conducted the arousal assessment. Abbreviations. Chinese Affective Picture System (CAPS; Lu et al., 2005); FEBA face repository (Gur et al., 2002); Karolinska Directed Emotional Faces (KDEF; Lundqvist et al., 1998); Pictures of Facial affect test (POFA; Ekman and Friesen, 1976); Ishai-NIMH set (Ishai et al., 2004); NimStim Set of Facial Expressions (Tottenham et al., 2009). Happy faces (H); Fearful faces (F); Angry faces (A); Sad faces (S); Neutral faces (Neu). Negative emotional faces (Neg); Positive emotional faces (Pos).

(Mancini et al., 2020, 2022; Mirabella, 2018; Montalti and Mirabella, 2023, 2024). Not surprisingly, the results of the 12 studies using Hare's design vary considerably, particularly regarding the impact of emotional expressions on commission and omission error rates (see Table 4). However, one finding appears to be more consistent across the studies: 9 out of 12 articles (75 %) reported that negative images led to longer RT compared to positive expressions (Carvalho Fernando et al., 2013; Ma et al., 2013; Putman et al., 2010; Quaglia et al., 2019; Schlosser et al., 2013; Schulz et al., 2007; Tamietto et al., 2006; Zhang et al., 2016). The remaining studies found no significant differences (Quaglia et al., 2016; Schulz et al., 2009; Yu et al., 2015). Interestingly, in four cases, the same authors obtained different results despite using the same task (Quaglia et al., 2016, 2019; Schulz et al., 2009, 2007). In the remaining eight studies emotional facial pictures were presented as go- and no-go signals and their valence was task-irrelevant (see Table 4). All these studies required participants to respond according to the posers' gender. In six articles (75 %) images valence elicited no differences in RT, omission, or commission errors (see Table 4; Mancini et al., 2020, 2022; Mirabella, 2018; Montalti and Mirabella, 2023; Montalti and Mirabella, 2024; Yu et al., 2015). Zhang and Lu (2012) found no differences in behavioral parameters between positive and negative expressions, but both types of emotional faces led to shorter RT and a higher rate of omission errors compared to neutral faces. Finally, Zhang et al. (2020) showed that negatively valenced faces have a distinct effect compared to positive faces, leading to longer RT and higher rates of both omission and commission errors.

Seven additional studies examined the influence of task-irrelevant emotional faces using distinct experimental approaches (see Table 4). Two of these studies (Parkinson et al., 2017; Steffen et al., 2009) used facial images as primes and found no significant differences in RT when comparing negative and neutral faces or negative and positive faces, respectively. In three other studies (Pacheco-Unguetti et al., 2012; Sinke et al., 2017; Yeung et al., 2024) participants performed discrimination tasks in which letters, shapes, or numbers were superimposed on facial images. While two studies (Sinke et al., 2017; Yeung et al., 2024) reported no differences in RT or omission and commission error rates across emotional expressions, Pacheco-Unguetti et al. (2012) found that negative facial expressions led to longer RT compared to positive and neutral faces, which did not differ from each other. Additionally, Liu et al. (2021) presented emotional faces prior to the go/no-go signals and found no significant differences of RT between positive and negative faces. In contrast, Maxwell et al. (2005) simultaneously displayed emotional faces centrally with go- and no-go signals appearing either in the left or right visual field. Their findings indicated that commission errors were higher for negative faces compared to positive faces only when the no-go signal was presented in the left visual field. Instead, commission error rates for neutral faces were comparable to those for both positive and negative faces.

To summarize the findings, we separately visualized the impact of task relevance of emotional expressions on response readiness and reactive inhibitory control (Figs. 5G and 5H). For the response readiness summary, we aggregated the outcomes of image valence on RT and omission errors in the go-trials of the Go/No-go tasks, distinguishing between task-relevant and task-irrelevant conditions (Fig. 5G). For the reactive inhibition summary, we summed up the outcomes of image valence affected on commission errors in the no-go trials (Fig. 5H). The overall result shows a clear trend, as far as response readiness is concerned. In this case, when the emotional content is task-irrelevant, the valence of the images does not affect the response in 36 out of 44 or 81.8 % of times, and in the few remaining cases no clear patterns emerges. By contrast, when emotional expressions are relevant to the task, the most evident effect (19 out of 39 or 48.7 % of times) is that negatively valenced faces lead to longer RT and higher rate of omission errors. However, in a consistent number of cases (29 out of 64 or 45.3 %) also task-relevant images had no effect on behavioral parameters. The lack of an effect of the valence of task-relevant emotional stimuli occurs more frequently for omission errors (46.2 %) than for RT (30.8 %). Such an outcome is expected, as the omission error rates average 5.8 ± 4.6 % across all studies and emotional faces, i.e., the error rates are low and highly variable, especially when multiple experimental conditions are present (e.g., Mancini et al., 2020; Montalti and Mirabella, 2024).

This observation may also provide insight into the overall findings on reactive inhibitory control (Fig. 5H). Similar to response readiness, when emotional stimuli are irrelevant to the task, their valence does not

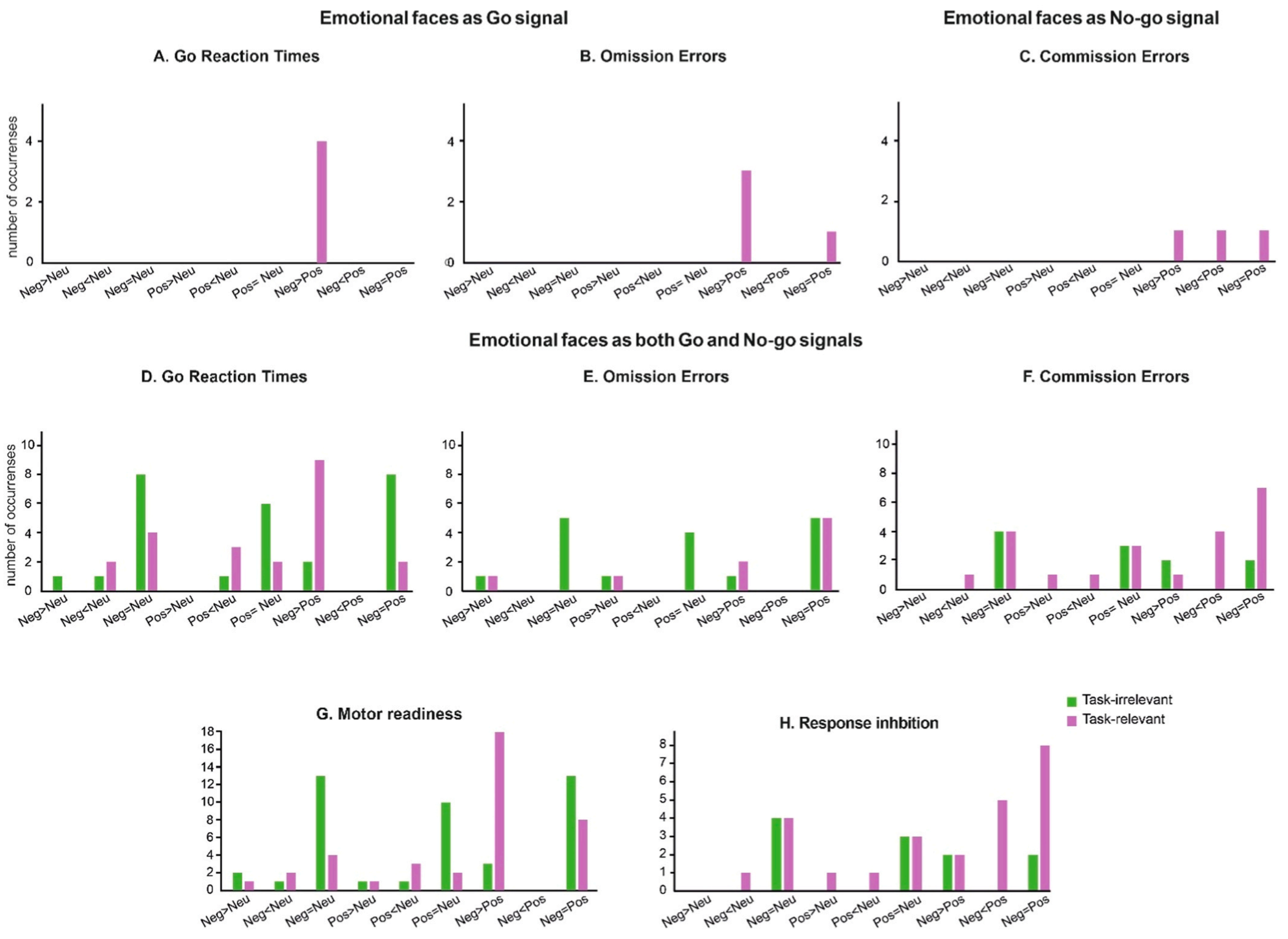


**Fig. 5. Summary of Go/No-go task studies' results**. Bar plots illustrate the absolute frequency of each possible outcome related to the reaction times (RT), omission, and commission errors. For instance, "Neg>Pos" indicates that negatively valenced faces resulted in longer RT compared to positive faces. In all cases, outcomes were categorized based on statistical significance, specifically when the comparison between emotional stimuli of different valences yielded a p-value< 0.05. The data is categorized based on the relevance of emotional stimuli in the task: task-irrelevant (green) and task-relevant (lilac). (A) Displays RT occurrences in studies where emotional faces were used solely as go-signals; (B) Displays omission error occurrences in the same studies. (C) Shows commission error occurrences in studies where emotional faces were used exclusively as no-go signals; (D) Displays RT occurrences in studies where emotional faces functioned as both go- and no-go signals; (E) Displays omission error occurrences; (F) Displays commission error occurrences in the same studies; (G) Displays the overall occurrences of behavioral parameters associated with response readiness (RT and omission errors) across all Go/No-go studies, and (H) shows the overall occurrences of commission errors, indexing reactive inhibitory control, across all Go/No-go studies. Abbreviations: Negative valence images (Neg); Neutral valence images (Neu); Positive valence images (Pos).

influence reactive inhibition in most cases (9 out of 11, i.e., 81.8 %). However, even when emotional stimuli are task-relevant, 15 out of 25 or 60 % of cases show no impact, while in the 6 out of 25 or 24 % of times negative images improve reactive inhibitory control with respect positive expressions by lowering the rate of commission errors. The weak impact on commission errors when emotional stimuli are task-relevant is because the design of the Go/No-go task inherently requires a strong tendency to respond (Wessel, 2018; Young et al., 2018), resulting in a lower proportion of no-go trials, typically only 25 % or 33 % of the total. With a limited number of no-go trials and an average commission error rate of 13.5 ± 8.1 % across all studies and emotional stimuli, the impact of image valence is derived from a small sample size, resulting in high variability in the overall findings.

Again, as for the SST, this evidence must be interpreted with consideration of several confounding factors. Firstly, in 18 out of 27 studies (66.6 %, see Table 4), image arousal was either not assessed (n = 17) or was not included in the statistical analyses despite differences in emotional face values (n = 1). Secondly, in five studies (18.5 %), the proportion of go trials was equal to (Ma et al., 2013; Steffen et al., 2009; Zhang and Lu, 2012) or even lower than that of the no-go trials (Liu et al., 2021; Yeung et al., 2024). Under such conditions, contrary to recommendations for optimal Go/No-go task design (Wessel, 2018; Young et al., 2018), the prepotent response tendency cannot be adequately induced. Third, 18 papers (66.6 %) did not report effect size measurements for post-hoc comparisons (see Supplementary Material), raising concerns about the robustness of the observed effects (Sullivan and Feinn, 2012). Taking these confounding factors into account, it emerges that the findings of 22 papers (81.5 %) have limitations that affect their interpretability. Notably, the studies conducted using Mirabella's design (Mancini et al., 2020, 2022; Mirabella, 2018; Montalti and Mirabella, 2023, 2024) stand out as a notable exception to these issues.

A final important consideration is that the existing literature has focused solely on measuring reactive inhibitory control, assessed through commission error rates, while overlooking proactive inhibition Table 4.

**Table 4**
Features and key findings of Go/No-go task studies.

| Article | Number and sex of participants | Mean Age ± SD [range] years | Task | Task-Relevance of emotional stimuli | Number of Trials | No-go frequency | Face Emotions (database/s) | Arousal assessment | Go RT | Omission Errors | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Articles where emotional faces were used only as Go signals (measuring response readiness)** | | | | | | | | | | | |
| Mancini et al. (2020)* | 56 (28 F) | 22.4 ± 2.4 | Go: emotional faces<br>No-go: neutral faces | **Relevant** | 396 | 33 % | H, F, A; Neu (POFA) | Yes°°°<br>H > F > A > Neu | Neg > Pos | Neg (A) > Pos<br>Neg (F) = Pos | |
| Mirabella (2018)* | 40 (20 F) | 24.9 ± 2.9 | Go: emotional faces<br>No-go: neutral faces | **Relevant** | 360 | 33 % | H, F, Neu (POFA) | Yes°°°<br>(F = H) > Neu | Neg > Pos | Neg > Pos | |
| Montalti and Mirabella (2023)* | 40 (20 F) | 23.6 ± 4.1 [19.9–32.5] | Go: emotional faces<br>No-go: neutral faces | **Relevant** | 576 | 33 % | H, F, Neu (KDEF) | Yes°°°<br>F > H > Neu | Neg > Pos | Neg > Pos | |
| Montalti and Mirabella (2024)* | 40 (20 F) | 24.5 ± 3.6 [19.7–32.9] | Go: emotional faces<br>No-go: neutral faces | **Relevant** | 432 | 33 % | H, A, F, Neu (KDEF) | Yes°°°<br>(A = F) > H > Neu | Neg(A) > Pos<br>Neg (F)=Pos | Neg = Pos | |
| **Articles where emotional faces were used only as No-Go signals (measuring inhibitory control)** | | | | | | | | | | | |
| Mancini et al. (2022)* | 40 (20 F) | 23.9 ± 4.7 [20−43] | Go: neutral faces<br>No-go: emotional faces | **Relevant** | 500–600 | 33 % | H, F, Neu (POFA) | Yes°°°<br>(F = H) > Neu | | Neg < Pos | |
| Pornpattananangkul et al. (2015) | 36 (21 F) | 18.6 ± N/A | Go: neutral faces<br>No-go: emotional faces | **Relevant** | 640 | 25 % | H, F, Neu (NimStim) | No | | Neg > Pos | |
| Zhu et al. (2024) | 41 (20 F) | 19.5 ± 0.3 | Go: neutral faces<br>No-go: emotional faces | **Relevant** | 192 | 25 % | F, A (CFAPS) | No | | Neg=Pos | |
| **Articles where emotional faces were used as both Go/No-go signals** | | | | | | | | | | | |
| Carvalho Fernando et al. (2013) | 32 (all F) | 29.5 ± 9.1 | Hare's Design^ | **Relevant** | 216 | 33 % | H, F, Neu (NimStim) | No | Neu > Neg > Pos | N/A | Neg = Pos = Neu |
| Ma et al. (2013) | 30 (22 F) | 21.4 ± 2.6 [18−28] | Hare's Design^ | **Relevant** | 240 | 50 % | H, Sa, Neu CFAPS | Yes°<br>Sa > H > Neu | Neg > Pos *[Neu not analyzed]* | Neg > Pos *[Neu not analyzed]* | Neg = Pos *[Neu not analyzed]* |
| Putman et al. (2010) | 28 (All F) | 22.7 ± 2.6 [19−28] | Hare's Design^ | **Relevant** | 384 | 25 % | H, F (KDEF) | No | Neg > Pos | N/A | Neg > Pos |
| Quaglia et al. (2016) | 58 (39 F) | 19.1 ± 2.1 | Hare's Design^ | **Relevant** | 960 | 30 % | H, F, Neu (NimStim) | No | Neg = Pos = Neu | N/A | Neg < (Pos = Neu) |
| Quaglia et al. (2019) | 26 (18 F) | 30.6 ± 9.1 [20−59] | Hare's Design^ | **Relevant** | 960 | 30 % | H, F, Neu (NimStim) | No | (Neg=Neu)> Pos | N/A | (Neg = Neu)<Pos |
| Schlosser et al. (2013) | 54 (35 F) | 31.5 ± 10.2 | Hare's Design^ | **Relevant** | 216 | 33 % | H, F, Neu (NimStim) | No | Neg<Neu; Pos<Neu; Neg > Pos | N/A | Neg=Neu; Pos<Neu; Neg = Pos |
| Schulz et al. (2007) | 85 (62 F) | 26.1 ± 10.8 [18−66] | Hare's Design^ | **Relevant** | 384 | 25 % | H, Sa (NimStim) | No | Neg>Pos | Neg=Pos | Neg < Pos |
| Schulz et al. (2009) | 24 (8 F) | [18−35] | Hare's Design^ | **Relevant** | 576 | 25 % | H, Sa, Neu (NimStim) | No | Neg = Pos = Neu | (Neg=Pos)> Neu | Neg = Pos = Neu |
| Tamietto et al. (2006) **(Experiment 2)** | 25 (20 F) | 25.3 ± 3.6 [19−32] | Hare's Design^ | **Relevant** | 1024 | 33 % | H, F, Neu (POFA) | No | Neg > Pos | Neg=Pos | Neg = Pos |
| Tamietto et al. (2006) **(Experiment 3)** | 20 (15 F) | 24.5 ± 3.8 [22−28] | Hare's Design^ | **Relevant** | 768 | 33 % | H, F (POFA) | No | Neg > Pos | Neg=Pos | Neg = Pos |
| Yu et al. (2015)* | 19 (10 F) | 26.6 ± 7.6 | Hare's Design^ | **Relevant** | 960 | 30 % | S, Neu (CFAPS) | Yes°°<br>S = Neu | Neg = Neu | N/A | N/A |
| Zhang et al. (2016) | 58 (31 F) | 22 ± 2.3 [18−26] | Hare's Design^ (before the task participants saw a negative or neutral video) | **Relevant** | 400 | 30 % | H, A (CFAPS) | Yes°°<br>H = A | Neg>Pos | Neg>Pos (after the negative video)<br>Neg=Pos (after the neutral video) | Neg<Pos (after the negative video)<br>Neg=Pos (after the neutral video) |
| Mancini et al. (2020)* | 56 (28 F) | 22.4 ± 2.4 | Gender discrimination | Irrelevant | 396 | 33 % | H, F, A, Neu (POFA) | Yes°°°<br>H > F > A > Neu | Neg = Pos = Neu | Neg = Pos = Neu | N/A |
| Mancini et al. (2022)* | 40 (20 F) | 23.9 ± 4.7 [20−43] | Gender discrimination | Irrelevant | 500–600 | 33 % | H, F, Neu (POFA) | Yes°°°<br>(F = H) > Neu | N/A | N/A | Neg = Pos = Neu |

(*continued on next page*)

**Table 4** (*continued*)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mirabella (2018)* | 40 (20 F) | 24.9 ± 2.9 | Gender discrimination | Irrelevant | 360 | 33 % | H, F, Neu (POFA) | Yes°°° (F = H) > Neu | Neg = Pos | Neg = Pos | N/A |
| Montalti and Mirabella (2023)* | 40 (20 F) | 23.6 ± 4.1 [19.9–32.5] | Gender discrimination | Irrelevant | 576 | 33 % | H, F, Neu (KDEF) | Yes°°° F > H > Neu | Neg = Pos = Neu | Neg = Pos = Neu | N/A |
| Montalti and Mirabella (2024)* | 40 (20 F) | 24.5 ± 3.6 [19.7–32.9] | Gender discrimination | Irrelevant | 432 | 33 % | H, A, F, Neu (KDEF) | Yes°°° (A = F) > H > Neu | Neg = Pos = Neu | Neg = Pos = Neu | N/A |
| Yu et al. (2015)* | 19 (10 F) | 26.6 ± 7.6 | Gender discrimination | Irrelevant | 960 | 30 % | S, Neu (CFAPS) | Yes°° S = Neu | Neg = Neu | N/A | N/A |
| Zhang and Lu (2012) | 20 (9 F) | [18–20] | Gender discrimination | Irrelevant | 324 | 50 % | H, A, F, Neu (CFAPS) | Yes°° H = A = F = Neu | (Neg = Pos) < Neu | (Neg = Pos)> Neu | Neg = Pos = Neu |
| Zhang et al. (2020) | 28 (23 F) | 24.2 ± 4.9 [17–39] | Gender discrimination (Before the face appeared, an emotional or neutral verb was presented subliminally) | Irrelevant | 480 | 30 % | H, A (CFAPS) | Yes°° H = A | Neg > Pos | Neg > Pos | Neg > Pos |
| **Articles where emotional faces were used as primes** | | | | | | | | | | | |
| Parkinson et al. (2017) **(Experiment 3)** | 16 (10 F) | 19.7 ± 1.6 | Color discrimination (faces used as primes) | Irrelevant | 720 | 16 % & 34 % choice trials | A, Neu (NimStim) | No | Neg = Neu | N/A | N/A |
| Steffen et al. (2009) | 21 (15 F) | 21.2 ± N/A [17–32] | Picture discrimination (faces used as primes) | Irrelevant | 1152 | 50 % | H, A (NimStim) | No | Neg = Pos | N/A | N/A |
| **Articles where emotional faces were printed in background** | | | | | | | | | | | |
| Pacheco-Unguetti et al. (2012) **(Experiment 1)** | 58 (37 F) | 25. 6 ± 7.5 | Letter discrimination (printed over faces' images) | Irrelevant | 360 | 33 % | H, A, Neu (KDEF, FACS, NimStim) | No | Neg > (Pos = Neu) | N/A | N/A |
| Sinke et al. (2017) | 16 (15 F) | 33.9 ± 13.8 | Shape discrimination (printed over faces' images) | Irrelevant | 450 | 30 % | H, A, Neu (NimStim) | No | Neg = Pos = Neu | N/A | N/A |
| Yeung et al. (2024) | 45 (29 F) | 20.7 ± 0.7 [18–39] | Number discrimination (printed over faces' images) | Irrelevant | 384 | 75 % | A, F, Neu (TFED) | No | Neg = Neu | Neg = Neu | Neg = Neu |
| **Articles where emotional faces were shown before or together the Go-signal** | | | | | | | | | | | |
| Liu et al. (2021) | 23 (13 F) | 22.2 ± 1.7 [19–26] | Orientation discrimination. (faces presented bilaterally before the Go-signal) | Irrelevant | 512 | 87.5 % | H, F, Neu (FACES) | No | Neg = Pos | N/A | N/A |
| Maxwell et al. (2005) | 43 (22 F) | [18–30] | Shape discrimination (faces centrally displayed, Go/No-go stimuli lateralized) | Irrelevant | 168 | 28.6 % | H, A, Neu (POFA) | No | N/A | N/A | Just when No-go were on the LVF Neg > Pos; Neg = Neu; Pos=Neu |

*Notes.* In bold *Papers appearing more times, for the following reasons: 1) Mancini et al. (2020), Mancini et al. (2022), Mirabella (2018), Montalti and Mirabella (2023), Montalti and Mirabella (2024), and Yu et al. (2015) exploited a within-subjects design comparing the effect of facial expressions on the go signal when task-relevant and task-irrelevant. ° The arousal was assessed by a group of subjects different from those involved in the experiment; °° the arousal values were taken from the score of the original database; °°° the arousal was assessed by the same group of subjects who took part in the experiment. Omission error rates (i.e., when participants erroneously did not respond to the go stimulus); Commission error rates (i.e., when participants erroneously respond to the go-stimulus when a stop-signal is presented). Abbreviations: Karolinska Directed Emotional Faces (KDEF; Lundqvist et al., 1998); Pictures of Facial affect test (POFA; Ekman and Friesen, 1976); NimStim Set of Facial Expressions (Tottenham et al., 2009); FACES (Ebner et al., 2010); Facial Action Coding System (FACS; Ekman & Friesen, 1978); Tsinghua Facial Expression Database (TFED, Yang et al., 2020). Happy faces (H); Fearful faces (F); Angry faces (A); Sad faces (S); Surprised face (Su); Disgusted face (D); Neutral faces (Neu). Negative emotional faces (Neg); Positive emotional faces (Pos). Go trials reaction time (Go RT). Right visual field (RVF); Not available (N/A).

## 4. General discussion

Understanding how we react to emotionally salient external stimuli is highly important from both a scientific and clinical perspective. According to evolutionary theories, our nervous system has been shaped by ecological demands to automatically trigger survival actions in response to such stimuli (Frijda et al., 1989; Lang, 1995; Lang et al., 2000; Mobbs et al., 2015; Pourtois et al., 2013). This account has undoubtedly been the most popular over the past 25 years. However, despite its appealing and reasonable nature, the empirical evidence supporting it is highly contradictory (Belopolsky et al., 2011; Calbi et al., 2022; Devue and Grimshaw, 2017; Mancini et al., 2020, 2022; Mauersberger et al., 2024; Mirabella, 2018; Mirabella et al., 2024a; Mirabella et al., 2023; Mirabella et al., 2024b; Montalti and Mirabella, 2024; Stein et al., 2009; Victeur et al., 2020). In this review, we focused on facial expressions as they are a crucial form of non-verbal communication that complement and enhance verbal interactions by offering key insights into others' emotional states, needs, and intentions (Cowen et al., 2021; Jack and Schyns, 2015). Consequently, the ability to recognize and interpret facial expressions is essential for social cognition, enabling individuals to respond rapidly and appropriately in various social situations. This is why researchers have suggested that task-irrelevant emotional faces can bias attention and override ongoing goal-directed thoughts and actions (Carretié, 2014; Vuilleumier, 2005). Nevertheless, recent evidence challenges this view indicating that healthy individuals do not respond automatically to emotional faces but rather evaluate them based on their current goals (Belopolsky et al., 2011; Calbi et al., 2022; Devue and Grimshaw, 2017; Mancini et al., 2020, 2022; Mauersberger et al., 2024; Mirabella, 2018; Mirabella et al., 2024a; Mirabella et al., 2023; Mirabella et al., 2024b; Montalti and Mirabella, 2023, 2024; Stein et al., 2009; Victeur et al., 2020). This perspective aligns more closely with our ability to navigate crowded social environments where people display a wide range of facial expressions. If we reacted to every task-irrelevant emotional expression, we would become overwhelmed and unable to focus on achieving our goals. Accordingly, this review examined studies investigating whether and how facial emotions influence two key aspects of motor control, i.e., response readiness and inhibitory control, based on their relevance to current goals in healthy young adults Despite several concerns that significantly limit the interpretability of the results, our findings suggest that existing research supports the idea that the valence of emotional faces affects behavioral responses only when they are task-relevant.

### 4.1. Overview of findings from the literature

To provide a comprehensive overview of the results across all experiments, we compiled all findings (Fig. 6). The findings show that when facial expressions are task-irrelevant, their emotional valence does not influence behavioral responses in approximately 74 % of cases (70 out of 95). In contrast, when the emotional content is task-relevant, emotional faces have no effect in 42.3 % of cases (30 out of 71). To assess the impact of stimulus relevance, we conducted a chi-squared test of independence, which was significant ($\chi^2(1) = 15.47$, $p < 0.0001$, $\varphi = .31$), indicating a difference in outcome frequencies between task-relevant and task-irrelevant conditions. This result was further supported by a strong Bayes factor ($BF_{10} > 100$), providing robust evidence in favor of the alternative hypothesis. This analysis suggests that emotional stimuli, when task-irrelevant, do not influence behavioral responses, whereas task relevance tend to introduce an effect. Specifically, under task-relevant conditions, negative facial expressions impaired motor control in 38 % of cases (8.4 % relative to neutral faces and 29.6 % relative to positive faces). As detailed above, results based on RT and SSRT are more consistent than those based on omission and commission errors because the latter ones are typically computed from a small number of trials.

In our opinion, the overall picture remains unclear due to several confounding factors. First, image arousal was not evaluated in 25 out of 42 studies (59.5 %) and was omitted from statistical analyses, despite differences in emotional face values being observed in 7 out of 42 studies (16.6 %). As a result, in 76.2 % of the studies, it remains unclear whether the findings were influenced by face valence, arousal, or both. Secondly, effect sizes for post hoc comparisons were not provided in 23 studies (54.8 %), and only four articles (9.5 %; Mancini et al., 2020, 2022; Montalti and Mirabella, 2023; Montalti and Mirabella, 2024) quantified the strength of the null hypothesis using Bayes factors (Rouder and Morey, 2009; Rouder et al., 2012, 2009). Consequently, in most cases, the robustness of the reported effects is very uncertain. Third, numerous studies had notable design weaknesses that restricted the interpretability of their findings, as outlined in Sections 3.3.1 and 3.3.2. Fourth, individual variability has largely been overlooked. Yet, factors such as personality traits, personality-related constructs like alexithymia, trait anxiety or emotion regulation strategies, and even cultural background can profoundly influence how emotionally salient stimuli are processed and translated into behavior. Fifth, with the exception of seven studies (Liang et al., 2022; Mancini et al., 2020, 2022; Mirabella, 2018; Montalti and Mirabella, 2023, 2024; Yu et al., 2015), no other research has examined the effect of task-relevance of emotional stimuli within the same group of participants and thus controlling for intersubject variability. Nonetheless, the most effective way to investigate this question is through a within-participants design, where the same group of people is exposed to identical images under two conditions: once when the images are relevant to the task and once when they are not. Notably, in these studies, task-irrelevant emotional faces never influenced behavioral responses, whereas the same images had an effect in 9 out of 11 cases (81.8 %) when they were task-relevant. Among these instances, negative facial expressions impaired motor control 89 % of the time. The two instances where task-relevant emotional stimuli did not produce a behavioral effect were: (a) the omission error rate in Montalti and Mirabella (2024) and this can be attributed to the low overall error rate and the large number of experimental conditions; (b) The RT in Yu et al. (2015), where the relatively small sample size ($n = 19$) may have limited the statistical power to detect an effect. Although few studies have utilized a within-subjects design, the findings from these studies provide a much clearer picture compared to other research. Therefore, adopting this approach in future studies is strongly recommended.

### 4.2. The compatibility of the goal-relevance hypothesis with leading Emotion Theories

After decades of neglect, the study of emotion processing has known a renaissance in the last 25–30 years (LeDoux, 2012). Emotion research was a 'victim' of early cognitive science, which, around the 1950s, shifted the interest from the relation between psychological functions and neural mechanisms toward processes that could be thought of in terms of computer-like operations. The mind was modeled like a computer, emphasizing rational thought and downplaying emotional influences. Such an approach allowed cognitive scientists to study mental processes leaving aside the problem of subjective experiences. Thus, for instance, cognitive scientists figured out how to study the ways the mind computes and represents external stimuli ignoring the tricky issue of how conscious perceptual experiences come about. Most cognitive processes occur unconsciously, and just some of them reach awareness, usually near the end of the computations. By contrast, the dark cloud of subjectivity hung over the topic of emotion. However, around 2000, the pioneering work of Le Doux, Damasio, Panksepp, Ekman, Davidson, Barrett, and Adolphs paved the way for a novel approach to the study of emotions. LeDoux (2012) began with the premise that some aspects of human emotion are rooted in evolutionary pressures, particularly responses related to survival and reproduction, such as reactions to danger, hunger, thirst, or potential mates. He proposed that to study how the brain processes emotions without falling into the problem of subjectivity, researchers could focus on how' survival circuits' detect key environmental information to control behavioral and internal physiological responses that serve specific adaptive purposes (LeDoux, 1996, 2012). As survival circuits are present in other mammals (and in other animals), they might be excellent models to study this type of emotion processing. Given this, the motivational model proposed by Bradley et al. (2001); Lang and Bradley (2010) to interpret behavioral reactions to emotional stimuli in humans seems straightforward. As

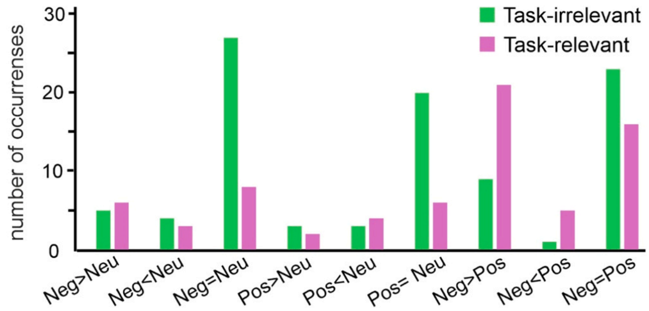


**Fig. 6.** Summary of all task studies' results. The barplot illustrates the absolute frequency of each possible outcome of all behavioral parameters measured using the Stop-signal task and the Go/No-go task (stop signal reaction time or SSRT, reaction time or RT of go-trials, omission and commission errors). For instance, "Neg>Pos" indicates that negatively valenced faces resulted in longer SSRT, RT, omission and commission errors compared to positive faces. In all cases, outcomes were categorized based on statistical significance, specifically when the comparison between emotional stimuli of different valences yielded a p-value$<$ 0.05.

mentioned in the Introduction, this model proposes that stimuli with either positive or negative emotional value automatically draw selective attention, are given processing priority, and activate the appetitive or defensive systems accordingly. Consequently, behavioral responses are triggered automatically, regardless of the individual's current goals (Lang et al., 2000; Vuilleumier, 2005). However, as this review demonstrates, the empirical evidence on how emotional stimuli affect motor control is largely inconsistent with this hypothesis. While several methodological confounds discussed in previous sections may contribute to these discrepancies, we argue that the key factor underlying the conflicting findings is the relevance of the emotional stimuli to the individual's current goal. A series of groundbreaking research on healthy subjects provides stringent evidence that, at least in low threat conditions such as those occurring in laboratories, emotional items do not automatically bias attention and influence behavioral reactions. Instead, they modulate motor responses when subjects are explicitly instructed to decide based on the emotional content (Belopolsky et al., 2011; Calbi et al., 2022; Devue and Grimshaw, 2017; Mancini et al., 2020, 2022; Mauersberger et al., 2024; Mirabella, 2018; Mirabella et al., 2024a; Mirabella et al., 2023; Mirabella et al., 2024b; Montalti and Mirabella, 2023, 2024; Stein et al., 2009; Victeur et al., 2020).

In contrast, the notion that goal relevance is central to emotional processing is well supported by appraisal theories (Moors et al., 2013; Moors and Fischer, 2019). These theories suggest that emotional responses are shaped by multiple factors, including an individual's goals, past experiences, current mood, and expectations. Consequently, emotional responses are not automatic; rather, they result from conscious or unconscious appraisals of a stimulus, shaped by context and personal goals.

Furthermore, Barrett's theory of constructed emotion (Barrett, 2006a, 2006b) is also compatible with the view that goal relevance can play a central role in shaping emotional responses. This framework challenges the assumption that emotionally salient stimuli automatically trigger fixed emotional reactions. Instead, it posits that the brain constructs emotions in real time by interpreting internal bodily signals and external contextual information. Thus, emotions are not direct responses to stimuli but are context-dependent predictions created by the brain to guide behavior, influenced by goals, context, and prior experiences.

The main difference between the theory of constructed emotion and appraisal theories lies in their view of biological determinism. The theory of constructed emotion denies the existence of biologically hardwired emotional responses, arguing instead that emotions are constructed through predictions based on prior experiences and context. In contrast, appraisal theories suggest that while some emotional tendencies may have evolutionary roots, emotional responses are largely shaped by cognitive appraisals, allowing for variability based on an individual's interpretation of the situation.

To the best of our knowledge, only one other systematic review has examined the effects of emotional stimuli on response inhibition with respect to their valence, arousal, and task relevance (Rincón-Pérez et al., 2025). Similar to the present review, Rincón-Pérez et al., (2025) noticed several critical methodological limitations in the existing literature, which complicate the interpretation of findings. Nevertheless, in partial alignment with our conclusions, they observed that behavioral effects on response inhibition are more frequently reported when the emotional content of stimuli is task-relevant, compared to when it is not. Moreover, like our review, they emphasized that in studies using a within-subject experimental design, only task-relevant emotional stimuli consistently influence performance, underscoring the need to control for individual differences to obtain clearer results.

## 5. Challenges and future directions

One unresolved challenge in all the reviewed studies on facial expressions is that those stimuli used lack ecological validity. Displaying two-dimensional, static, stereotypical-posed faces on a screen in front of participants is far from replicating a realistic social interaction (Holleman et al., 2021; Shamay-Tsoory and Mendelsohn, 2019). In real life, facial expressions are dynamic and occur within rich, context-dependent environments (Aviezer et al., 2017). Nonverbal cues such as body language, prior knowledge of a person, and the social context in which individuals operate are all essential for interpreting the meaning of emotional facial expressions and likely affect behavioral responses. As such, it seems reasonable to suggest that isolated emotional faces may not be sufficiently salient to capture attention. The use of immersive virtual reality environments provides a promising way to address these limitations by simulating the complexity of emotional reactions in real-world situations (González-Gualda et al., 2024). Interactive environments allow for the creation of various scenarios where participants can engage with objects and avatars in real time, offering the sensation of being physically present and thus truly experiencing emotions (Marín-Morales et al., 2020).

In summary, based on the points discussed above, future research should consider the following directions: (a) examine the role of goal-relevance in emotional processing by employing within-group comparisons to account for intersubject variability; (b) use emotional stimuli with higher ecological validity, such as dynamic stimuli or virtual reality scenarios; (c) explore the link between emotional stimuli and proactive inhibition, an area that remains under-investigated despite its relevance, particularly given that this domain of inhibitory control is often impaired in various neurological and psychiatric disorders (Mirabella, 2021); (d) measure arousal (using either a Likert scale or the Self-Assessment Manikin, Bradley and Lang, 1994) and including it into the statistical analyses as needed, to ascribe the observed effect to one of the two dimensions of the emotional stimuli, i.e., valence, arousal or both; (e) ensure adequate statistical power by recruiting sufficiently large sample sizes ($n > 30$; Fagerland, 2012); (f) apply Bayesian statistical methods to yield robust estimates of the strength of both null and alternative hypotheses (Rouder and Morey, 2009; Rouder et al., 2012, 2009); (g) consider individual differences, such as personality traits, personality-related constructs (e.g., alexithymia, impulsivity, trait anxiety, and emotion regulation strategies), and cultural background, as these factors are likely to influence how emotional information is processed.

## 6. Conclusions

On average, the quality of most existing studies on the effect of facial expressions on behavioral responses is relatively low. Numerous confounding factors significantly undermine the interpretability of the findings, leading to an incomplete and unsatisfactory understanding of the topic.

However, current research confirms that task-irrelevant emotional facial expressions do not influence behavioral responses. In contrast, when the emotional content of faces aligns with participants' goals, their valence does have an effect. Regarding response readiness, most findings suggest that negative expressions slow RT and increase omission errors, likely because these images hold attention stronger than positive faces. This heightened attention may stem from participants evaluating whether such expressions signal a real threat (Mirabella et al., 2024a). The impact on inhibitory control, however, remains more contentious, requiring further investigation. Nonetheless, the findings of Mancini et al. (2022) on emotional facial expressions and Calbi et al. (2022) on emotional body postures, which suggest that negative expressions enhance inhibitory control compared to positive ones, are reasonable. Since negative expressions tend to draw attention and slow movement execution more than positive expressions, it follows that they may also increase the likelihood of movement suppression. Overall, the findings of this review strongly support the idea that the evaluation of emotional stimuli is the key factor influencing behavioral responses (Moors and Fischer, 2019; Scherer and Moors, 2019). In other words, emotional stimuli do not automatically trigger behavioral reactions. Before concluding, we want to clarify that we do not entirely dismiss the possibility that, in life-threatening situations, emotional stimuli could automatically trigger behavioral responses. However, such extreme events are rare in everyday life. Additionally, we acknowledge that task-irrelevant stimuli may still influence brain activity, likely reflecting the neural mechanisms underlying appraisal processes. Finally, it is important to emphasize that our findings apply specifically to healthy individuals. Mental and neurological disorders may significantly alter emotion processing, thereby affecting behavior. To fully understand these disruptions in emotional regulation, it is essential first to establish a comprehensive understanding of how these processes function in a healthy population.

## Author contributions

GM conceived the presented idea. MM carried out the systematic literature search, and wrote the first draft of the present manuscript. MM and GM interpreted and discussed the results, provided critical feedback and approved the submitted version.

## Funding

This work was supported by the Italian Ministry of University and Research (MUR), Grant/Award Number: (a) Projects of great national interest (PRIN) National Recovery and Resilience Plan (NRRP) P2022KAZ45; (b) The improvement of psychophysical well-being in the university context (PRO-BEN) PROBEN_0000013; (c) PRIN 20225PFP7L; and (d) Department of Clinical and Experimental Sciences of the University of Brescia, Grant/Award Number: Departments of Excellence 2023−2027 (IN2DEPT Innovative and Integrative Department Platforms).

## Declaration of Competing Interest

none.

## Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.neubiorev.2025.106289.

## References

Aviezer, H., Ensenberg, N., Hassin, R.R., 2017. The inherently contextualized nature of facial emotion perception. Curr. Opin. Psychol. 17, 47–54.
Bari, A., Robbins, T.W., 2013. Inhibition and impulsivity: behavioral and neural basis of response control. Prog. Neurobiol. 108, 44–79.
Barrett, L.F., 2006a. Are Emotions Natural Kinds? Perspect. Psychol. Sci. 1, 28–58.
Barrett, L.F., 2006b. Solving the emotion paradox: categorization and the experience of emotion. Pers. Soc. Psychol. Rev. 10, 20–46.
Battaglia, S., Cardellicchio, P., Di Fazio, C., Nazzi, C., Fracasso, A., Borgomaneri, S., 2022. The Influence of Vicarious Fear-Learning in "Infecting" Reactive Action Inhibition. Front. Behav. Neurosci. 16, 946263.
Belopolsky, A.V., Devue, C., Theeuwes, J., 2011. Angry faces hold the eyes. Vis. Cogn. 19, 27–36.
Berger, N., Richards, A., Davelaar, E.J., 2017. When Emotions Matter: Focusing on Emotion Improves Working Memory Updating in Older Adults. Front. Psychol. 8, 1565.
Blagrove, E., Watson, D.G., 2014. Ignoring real faces: Effects of valence, threat, and salience. Atten. Percept. Psychophys. 76, 725–745.
Bradley, M.M., Lang, P.J., 1994. Measuring emotion: The self-assessment manikin and the semantic differential. J. Behav. Ther. Exp. Psychiatry 25, 49–59.
Bradley, M.M., Codispoti, M., Cuthbert, B.N., Lang, P.J., 2001. Emotion and motivation I: defensive and appetitive reactions in picture processing. Emotion 1, 276–298.
Calbi, M., Montalti, M., Pederzani, C., Arcuri, E., Umiltà, M.A., Gallese, V., Mirabella, G., 2022. Emotional body postures affect inhibitory control only when task-relevant. Front. Psychol. 13, 1035328.
Carretié, L., 2014. Exogenous (automatic) attention to emotional stimuli: a review. Cogn. Affect. Behav. Neurosci. 14, 1228–1258.
Carvalho Fernando, S., Beblo, T., Schlosser, N., Terfehr, K., Wolf, O.T., Otte, C., Lowe, B., Spitzer, C., Driessen, M., Wingenfeld, K., 2013. Acute glucocorticoid effects on response inhibition in borderline personality disorder. Psychoneuroendocrinology 38, 2780–2788.
Cecere, R., Bertini, C., Ladavas, E., 2013. Differential contribution of cortical and subcortical visual pathways to the implicit processing of emotional faces: a tDCS study. J. Neurosci. 33, 6469–6475.
Cohen, J., 1960. A Coefficient of Agreement for Nominal Scales. Educ. Psychol. Meas. 20, 37–46.
Cowen, A.S., Keltner, D., Schroff, F., Jou, B., Adam, H., Prasad, G., 2021. Sixteen facial expressions occur in similar contexts worldwide. Nature 589, 251–257.
Crivelli, C., Fridlund, A.J., 2018. Facial Displays Are Tools for Social Influence. Trends Cogn. Sci. 22, 388–399.
Daley, R.T., Bowen, H.J., Fields, E.C., Parisi, K.R., Gutchess, A., Kensinger, E.A., 2020. Neural mechanisms supporting emotional and self-referential information processing and encoding in older and younger adults. Soc. Cogn. Affect. Neurosci. 15, 405–421.
van den Wildenberg, W.P.M., Ridderinkhof, K.R., Wylie, S.A., 2022. Towards Conceptual Clarification of Proactive Inhibitory Control: A Review. Brain Sci. 12.
Devue, C., Grimshaw, G.M., 2017. Faces are special, but facial expressions aren`t: Insights from an oculomotor capture paradigm. Atten. Percept. Psychophys. 79, 1438–1452.
Diamond, A., 2013. Executive functions. Annu. Rev. Psychol. 64, 135–168.
Ding, J., Wang, Y., Wang, C., d'Oleire Uquillas, F., He, Q., Cheng, L., Zou, Z., 2020. Negative Impact of Sadness on Response Inhibition in Females: An Explicit Emotional Stop Signal Task fMRI Study. Front. Behav. Neurosci. 14, 119.
Donders, F.C., 1969. On the speed of mental processes. Acta Psychol. (Amst. ) 30, 412–431.
Ebner, N.C., Riediger, M., Lindenberger, U., 2010. FACES–a database of facial expressions in young, middle-aged, and older women and men: development and validation. Behav. Res. Methods 42, 351–362.
Ekman, P., Friesen, W.V., 1971. Constants across cultures in the face and emotion. J. Pers. Soc. Psychol. 17, 124–129.
Ekman, P., Friesen, W.V., 1976. Pictures of facial affect. Consulting Psychologists Press, Palo Alto, Calif.
Ekman, P., Friesen, W.V., 1978. Facial Action Coding System: A Technique for the Measurement of Facial Movement. Consulting Psychologists Press, Palo Alto, CA.
Fagerland, M.W., 2012. t-tests, non-parametric tests, and large studies—a paradox of statistical practice? BMC Med. Res. Method. 12, 78.
Fischer, A., Hess, U., 2017. Mimicking emotions. Curr. Opin. Psychol. 17, 151–155.
Frijda, N.H., Kuipers, P., ter Schure, E., 1989. Relations among emotion, appraisal, and emotional action readiness. J. Pers. Soc. Psychol. 57, 212–228.
González-Gualda, L.M., Vicente-Querol, M.A., García, A.S., Molina, J.P., Latorre, J.M., Fernández-Sotos, P., Fernández-Caballero, A., 2024. An exploratory study of the effect of age and gender on face scanning during affect recognition in immersive virtual reality. Sci. Rep. 14, 5553.
Gupta, R., Singh, J.P., 2021. Only irrelevant angry, but not happy, expressions facilitate the response inhibition. Atten. Percept. Psychophys. 83, 114–121.
Gupta, R., Singh, J.P., 2023. Irrelevant emotional expressions interfered with response inhibition: the role of contrast emotions. J. Cogn. Psychol. 35, 677–687.
Gur, R.C., Sara, R., Hagendoorn, M., Marom, O., Hughett, P., Macy, L., Turner, T., Bajcsy, R., Posner, A., Gur, R.E., 2002. A method for obtaining 3-dimensional facial expressions and its standardization for use in neurocognitive studies. J. Neurosci. Methods 115, 137–143.
Hare, T.A., Tottenham, N., Davidson, M.C., Glover, G.H., Casey, B.J., 2005. Contributions of amygdala and striatal activity in emotion regulation. Biol. Psychiatry 57, 624–632.

Holleman, G.A., Hooge, I.T.C., Kemner, C., Hessels, R.S., 2021. The Reality of "Real-Life" Neuroscience: A Commentary on Shamay-Tsoory and Mendelsohn (2019). Perspect. Psychol. Sci. 16, 461–465.
Ishai, A., Pessoa, L., Bikle, P.C., Ungerleider, L.G., 2004. Repetition suppression of faces is modulated by emotion. Proc. Natl. Acad. Sci. U. S. A. 101, 9827–9832.
Jack, R.E., Schyns, P.G., 2015. The Human Face as a Dynamic Tool for Social Communication. Curr. Biol. 25, R621–R634.
Jia, L.X., Zheng, Q., Cui, J.F., Shi, H.S., Ye, J.Y., Yang, T.X., Wang, Y., Chan, R.C.K., 2023. Proactive and reactive response inhibition of individuals with high schizotypy viewing different facial expressions: An ERP study using an emotional stop-signal task. Brain Res 1799, 148191.
Kendall, L.N., Raffaelli, Q., Kingstone, A., Todd, R.M., 2016. Iconic faces are not real faces: enhanced emotion detection and altered neural processing as faces become more iconic. Cogn. Res. Princ. Implic. 1, 19.
Lang, P.J., 1995. The emotion probe: Studies of motivation and attention. Am. Psychol. 50, 372–385.
Lang, P.J., 2005. International affective picture system (IAPS): Affective ratings of pictures and instruction manual. Technical report.
Lang, P.J., Bradley, M.M., 2010. Emotion and the motivational brain. Biol. Psychol. 84, 437–450.
Lang, P.J., Bradley, M.M., Cuthbert, B.N., 1997. Motivated attention: Affect, activation, and action, Attention and orienting: Sensory and motivational processes. Lawrence Erlbaum Associates Publishers, Mahwah, NJ, US, pp. 97–135.
Lang, P.J., Davis, M., Ohman, A., 2000. Fear and anxiety: animal models and human cognitive psychophysiology. J. Affect. Disord. 61, 137–159.
LeDoux, J., 1996. The Emotional Brain. Simon and Schuster, New York.
LeDoux, J., 2012. Rethinking the emotional brain. Neuron 73, 653–676.
Liang, J.N., Hu, W.T., Gu, Y.T., Cheng, T.H., Geng, J.S., Wang, K.L., Wang, L.J., Yao, X.R., Shen, J.F., Wang, Y.Y., 2022. Impairment of response inhibition to emotional face stimuli in individuals with subclinical depression. Psych. J. 11, 327–334.
Liberati, A., Altman, D.G., Tetzlaff, J., Mulrow, C., Gøtzsche, P.C., Ioannidis, J.P., Clarke, M., Devereaux, P.J., Kleijnen, J., Moher, D., 2009. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. BMJ 339, b2700.
Lichtenstein-Vidne, L., Henik, A., Safadi, Z., 2012. Task relevance modulates processing of distracting emotional stimuli. Cogn. Emot. 26, 42–52.
Liu, H., Liu, Y., Dong, X., Liu, H., Han, B., 2021. Effect of Cognitive Control on Age-Related Positivity Effects in Attentional Processing - Evidence From an Event-Related Brain Potential Study. Front. Psychol. 12, 755635.
Lodha, S., Gupta, R., 2024. Irrelevant angry, but not happy, faces facilitate response inhibition in mindfulness meditators. Curr. Psychol. 43, 811–826.
Logan, G.D., 1994. On the ability to inhibit thought and action: A users' guide to the stop signal paradigm. In: Dagenbach, D., Carr, T.H. (Eds.), In: Inhibitory Processes in Attention, Memory and Language. Academic Press, San Diego.
Logan, G.D., Cowan, W.B., Davis, K.A., 1984. On the ability to inhibit simple and choice reaction time responses: a model and a method. J. Exp. Psychol. Hum. Percept. Perform. 10, 276–291.
Lu, B., Hui, M., Yu-Xia, H., 2005. The Development of Native Chinese Affective Picture System–A pretest in 46 College Students. Chin. Ment. Health J. 19, 719–722.
Lundqvist, D., Flykt, A., Öhman, A., 1998. Karolinska directed emotional faces. PsycTESTS Dataset.
Lundqvist, D., Juth, P., Öhman, A., 2014. Using facial emotional stimuli in visual search experiments: The arousal factor explains contradictory results. Cogn. Emot. 28, 1012–1029.
Ly, V., Cools, R., Roelofs, K., 2014. Aversive disinhibition of behavior and striatal signaling in social avoidance. Soc. Cogn. Affect. Neurosci. 9, 1530–1536.
Ma, Z., Li, J., Niu, Y., Yu, J., Yang, L., 2013. Age differences in emotion recognition between Chinese younger and older adults. Psychol. Rec. 63, 1–12.
Mancini, C., Falciati, L., Maioli, C., Mirabella, G., 2020. Threatening Facial Expressions Impact Goal-Directed Actions Only if Task-Relevant. Brain Sci. 10, 794.
Mancini, C., Falciati, L., Maioli, C., Mirabella, G., 2022. Happy facial expressions impair inhibitory control with respect to fearful facial expressions but only when task-relevant. Emotion 22, 142–152.
Marín-Morales, J., Llinares, C., Guixeres, J., Alcañiz, M., 2020. Emotion Recognition in Immersive Virtual Reality: From Statistics to Affective Computing. Sens. (Basel) 20.
Mauersberger, H., Blaison, C., Hess, U., 2024. Task-irrelevant emotional expressions are not mimicked, but may modulate the mimicry of task-relevant emotional expressions. Front. Psychol. 15, 1491832.
Maxwell, J.S., Shackman, A.J., Davidson, R.J., 2005. Unattended facial expressions asymmetrically bias the concurrent processing of nonemotional information. J. Cogn. Neurosci. 17, 1386–1395.
McRae, K., Gross, J.J., 2020. Emotion regulation. Emotion 20, 1–9.
Medicine, Io, Council, N.R., 2015. Investing in the Health and Well-Being of Young Adults. The National Academies Press, Washington, DC.
Mirabella, G., 2018. The Weight of Emotions in Decision-Making: How Fearful and Happy Facial Stimuli Modulate Action Readiness of Goal-Directed Actions. Front. Psychol. 9, 1334.
Mirabella, G., 2021. Inhibitory control and impulsive responses in neurodevelopmental disorders. Dev. Med. Child Neurol. 63, 520–526.
Mirabella, G., 2023. Beyond Reactive Inhibition: Unpacking the Multifaceted Nature of Motor Inhibition. Brain Sci. 13.
Mirabella, G., Pani, P., Pare, M., Ferraina, S., 2006. Inhibitory control of reaching movements in humans. Exp. Brain Res. 174, 240–255.
Mirabella, G., Pani, P., Ferraina, S., 2008. Context influences on the preparation and execution of reaching movements. Cogn. Neuropsychol. 25, 996–1010.
Mirabella, G., Grassi, M., Mezzarobba, S., Bernardis, P., 2023. Angry and happy expressions affect forward gait initiation only when task relevant. Emotion 23, 387–399.
Mirabella, G., Grassi, M., Bernardis, P., 2024a. The role of task relevance in saccadic responses to facial expressions. Ann. N. Y. Acad. Sci. 1540, 324–337.
Mirabella, G., Tullo, M.G., Sberna, G., Galati, G., 2024b. Context matters: task relevance shapes neural responses to emotional facial expressions. Sci. Rep. 14, 17859.
Mobbs, D., Hagan, C.C., Dalgleish, T., Silston, B., Prévost, C., 2015. The ecology of human fear: survival optimization and the nervous system. Front. Neurosci. 9, 55.
Montalti, M., Mirabella, G., 2023. Unveiling the influence of task-relevance of emotional faces on behavioral reactions in a multi-face context using a novel Flanker-Go/No-go task. Sci. Rep. 13, 20183.
Montalti, M., Mirabella, G., 2024. Investigating the impact of surgical masks on behavioral reactions to facial emotions in the COVID-19 era. Front. Psychol. 15, 1359075.
Moola, S., Munn, Z., Tufanaru, C., Aromataris, E., Sears, K., Sfetcu, R., Currie, M., Lisy, K., Qureshi, R., Mattis, P., Mu, P., 2020. Systematic reviews of etiology and risk in: Aromataris, E., Munn, Z. (Eds.), JBI Manual for Evidence Synthesis.
Moors, A., Fischer, M., 2019. Demystifying the role of emotion in behaviour: toward a goal-directed account. Cogn. Emot. 33, 94–100.
Moors, A., Ellsworth, P.C., Scherer, K.R., Frijda, N.H., 2013. Appraisal Theories of Emotion: State of the Art and Future Development. Emot. Rev. 5, 119–124.
Pacheco-Unguetti, A.P., Acosta, A., Lupianez, J., Roman, N., Derakshan, N., 2012. Response inhibition and attentional control in anxiety. Q. J. Exp. Psychol. (Hove. ) 65, 646–660.
Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E., Chou, R., Glanville, J., Grimshaw, J.M., Hróbjartsson, A., Lalu, M.M., Li, T., Loder, E.W., Mayo-Wilson, E., McDonald, S., McGuinness, L.A., Stewart, L.A., Thomas, J., Tricco, A.C., Welch, V.A., Whiting, P., Moher, D., 2021. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 372 n71.
Pandey, S., Gupta, R., 2022b. Irrelevant positive emotional information facilitates response inhibition only under a high perceptual load. Sci. Rep. 12, 14591.
Pandey, S., Gupta, R., 2022a. Irrelevant angry faces impair response inhibition, and the go and stop processes share attentional resources. Sci. Rep. 12, 16962.
Parkinson, J., Garfinkel, S., Critchley, H., Dienes, Z., Seth, A.K., 2017. Don't make me angry, you wouldn't like me when I'm angry: Volitional choices to act or inhibit are modulated by subliminal perception of emotional faces. Cogn. Affect. Behav. Neurosci. 17, 252–268.
Pawliczek, C.M., Derntl, B., Kellermann, T., Kohn, N., Gur, R.C., Habel, U., 2013. Inhibitory control and trait aggression: neural and behavioral insights using the emotional stop signal task. Neuroimage 79, 264–274.
Pessoa, L., Padmala, S., Kenzer, A., Bauer, A., 2012. Interactions between cognition and emotion during response inhibition. Emotion 12, 192–197.
Pornpattananangkul, N., Hu, X., Nusslock, R., 2015. Threat/reward-sensitivity and hypomanic-personality modulate cognitive-control and attentional neural processes to emotional stimuli. Soc. Cogn. Affect. Neurosci. 10, 1525–1536.
Pourtois, G., Schettino, A., Vuilleumier, P., 2013. Brain mechanisms for emotional influences on perception and attention: what is magic and what is not. Biol. Psychol. 92, 492–512.
Putman, P., van Peer, J., Maimari, I., van der Werff, S., 2010. EEG theta/beta ratio in relation to fear-modulated response-inhibition, attentional control, and affective traits. Biol. Psychol. 83, 73–78.
Quaglia, J.T., Goodman, R.J., Brown, K.W., 2016. Trait Mindfulness Predicts Efficient Top-Down Attention to and Discrimination of Facial Expressions. J. Pers. 84, 393–404.
Quaglia, J.T., Zeidan, F., Grossenbacher, P.G., Freeman, S.P., Braun, S.E., Martelli, A., Goodman, R.J., Brown, K.W., 2019. Brief mindfulness training enhances cognitive control in socioemotional contexts: Behavioral and neural evidence. PLoS One 14, e0219862.
Raymond, J.E., Shapiro, K.L., Arnell, K.M., 1992. Temporary suppression of visual processing in an RSVP task: an attentional blink? J. Exp. Psychol. Hum. Percept. Perform. 18, 849–860.
Rebetez, M.M., Rochat, L., Billieux, J., Gay, P., Van der Linden, M., 2015. Do emotional stimuli interfere with two distinct components of inhibition? Cogn. Emot. 29, 559–567.
Rincón-Pérez, I., Sánchez-Carmona, A.J., Levy, D., López-Martín, S., Hinojosa, J.A., Albert, J., 2025. The influence of emotional stimuli on response inhibition: a systematic review in non-clinical adults. Front. Psychol. 16, 2025.
Rouder, J.N., Morey, R.D., 2009. The nature of psychological thresholds. Psychol. Rev. 116, 655–660.
Rouder, J.N., Speckman, P.L., Sun, D., Morey, R.D., Iverson, G., 2009. Bayesian t tests for accepting and rejecting the null hypothesis. Psychon. Bull. Rev. 16, 225–237.
Rouder, J.N., Morey, R.D., Speckman, P.L., Province, J.M., 2012. Default Bayes factors for ANOVA designs. J. Math. Psychol. 56, 356–374.
Rutter, L.A., Dodell-Feder, D., Vahia, I.V., Forester, B.P., Ressler, K.J., Wilmer, J.B., Germine, L., 2019. Emotion sensitivity across the lifespan: Mapping clinical risk periods to sensitivity to facial emotion intensity. J. Exp. Psychol. Gen. 148, 1993–2005.
Schag, K., Sandler, L., Zipfel, S., Derntl, B., Giel, K.E., 2023. Inhibitory control towards angry stimuli in patients with binge eating disorder: a pilot study. J. Eat. Disord. 11, 125.
Scherer, K.R., Moors, A., 2019. The Emotion Process: Event Appraisal and Component Differentiation. Annu. Rev. Psychol. 70, 719–745.
Schlosser, N., Wolf, O.T., Fernando, S.C., Terfehr, K., Otte, C., Spitzer, C., Beblo, T., Driessen, M., Lowe, B., Wingenfeld, K., 2013. Effects of acute cortisol administration

on response inhibition in patients with major depression and healthy controls. Psychiatry Res 209, 439–446.
Schulz, K.P., Fan, J., Magidina, O., Marks, D.J., Hahn, B., Halperin, J.M., 2007. Does the emotional go/no-go task really measure behavioral inhibition? Convergence with measures on a non-emotional analog. Arch. Clin. Neuropsychol. 22, 151–160.
Schulz, K.P., Clerkin, S.M., Halperin, J.M., Newcorn, J.H., Tang, C.Y., Fan, J., 2009. Dissociable neural effects of stimulus valence and preceding context during the inhibition of responses to emotional faces. Hum. Brain Mapp. 30, 2821–2833.
Shamay-Tsoory, S.G., Mendelsohn, A., 2019. Real-Life Neuroscience: An Ecological Approach to Brain and Behavior Research. Perspect. Psychol. Sci. 14, 841–859.
Sinke, C., Wollmer, M.A., Kneer, J., Kahl, K.G., Kruger, T.H.C., 2017. Interaction between behavioral inhibition and emotional processing in borderline personality disorder using a pictorial emotional go/no-go paradigm. Psychiatry Res 256, 286–289.
Soloff, P.H., Abraham, K., Burgess, A., Ramaseshan, K., Chowdury, A., Diwadkar, V.A., 2017. Impulsivity and aggression mediate regional brain responses in Borderline Personality Disorder: An fMRI study. Psychiatry Res Neuroimaging 260, 76–85.
Song, S., Zou, Z., Song, H., Wang, Y., d'Oleire Uquillas, F., Wang, H., Chen, H., 2016. Romantic Love Is Associated with Enhanced Inhibitory Control in an Emotional Stop-Signal Task. Front. Psychol. 7, 1574.
Steffen, A.C., Rockstroh, B., Jansma, B., 2009. Brain evoked potentials reflect how emotional faces influence our decision making. J. Neurosci. Psychol. Econ. 2, 32–40.
Stein, T., Zwickel, J., Ritter, J., Kitzmantel, M., Schneider, W.X., 2009. The effect of fearful faces on the attentional blink is task dependent. Psychon. Bull. Rev. 16, 104–109.
Stockdale, L., Morrison, R.G., Palumbo, R., Garbarino, J., Silton, R.L., 2017. Cool, callous and in control: superior inhibitory control in frequent players of video games with violent content. Soc. Cogn. Affect. Neurosci. 12, 1869–1880.
Stockdale, L.A., Morrison, R.G., Kmiecik, M.J., Garbarino, J., Silton, R.L., 2015. Emotionally anesthetized: media violence induces neural changes during emotional face processing. Soc. Cogn. Affect. Neurosci. 10, 1373–1382.
Stockdale, L.A., Morrison, R.G., Silton, R.L., 2020. The influence of stimulus valence on perceptual processing of facial expressions and subsequent response inhibition. Psychophysiology 57, e13467.
Sullivan, G.M., Feinn, R., 2012. Using Effect Size-or Why the P Value Is Not Enough. J. Grad. Med. Educ. 4, 279–282.
Tamietto, M., Latini Corazzini, L., de Gelder, B., Geminiani, G., 2006. Functional asymmetry and interhemispheric cooperation in the perception of emotions from facial expressions. Exp. Brain Res. 171, 389–404.
Taylor, M.J., Robertson, A., Keller, A.E., Sato, J., Urbain, C., Pang, E.W., 2018. Inhibition in the face of emotion: Characterization of the spatial-temporal dynamics that facilitate automatic emotion regulation. Hum. Brain Mapp. 39, 2907–2916.
Tottenham, N., Tanaka, J.W., Leon, A.C., McCarry, T., Nurse, M., Hare, T.A., Marcus, D. J., Westerlund, A., Casey, B.J., Nelson, C., 2009. The NimStim set of facial expressions: judgments from untrained research participants. Psychiatry Res 168, 242–249.
Vandewouw, M.M., Safar, K., Sato, J., Hunt, B.A.E., Urbain, C.M., Pang, E.W., Anagnostou, E., Taylor, M.J., 2021. Ignore the faces: Neural characterisation of emotional inhibition from childhood to adulthood using MEG. Hum. Brain Mapp. 42, 5747–5760.
Verbruggen, F., Aron, A.R., Band, G.P., Beste, C., Bissett, P.G., Brockett, A.T., Brown, J. W., Chamberlain, S.R., Chambers, C.D., Colonius, H., Colzato, L.S., Corneil, B.D., Coxon, J.P., Dupuis, A., Eagle, D.M., Garavan, H., Greenhouse, I., Heathcote, A., Huster, R.J., Jahfari, S., Kenemans, J.L., Leunissen, I., Li, C.R., Logan, G.D., Matzke, D., Morein-Zamir, S., Murthy, A., Paré, M., Poldrack, R.A., Ridderinkhof, K. R., Robbins, T.W., Roesch, M., Rubia, K., Schachar, R.J., Schall, J.D., Stock, A.K., Swann, N.C., Thakkar, K.N., van der Molen, M.W., Vermeylen, L., Vink, M., Wessel, J.R., Whelan, R., Zandbelt, B.B., Boehler, C.N., 2019. A consensus guide to capturing the ability to inhibit actions and impulsive behaviors in the stop-signal task. Elife 8.
Victeur, Q., Huguet, P., Silvert, L., 2020. Attentional allocation to task-irrelevant fearful faces is not automatic: experimental evidence for the conditional hypothesis of emotional selection. Cogn. Emot. 34, 288–301.
Vuilleumier, P., 2005. How brains beware: neural mechanisms of emotional attention. Trends Cogn. Sci. 9, 585–594.
Wessel, J.R., 2018. Prepotent motor activity and inhibitory control demands in different variants of the go/no-go paradigm. Psychophysiology 55.
Williams, S.E., Lenze, E.J., Waring, J.D., 2020. Positive information facilitates response inhibition in older adults only when emotion is task-relevant. Cogn. Emot. 34, 1632–1645.
Windmann, S., Chmielewski, A., 2008. Emotion-induced modulation of recognition memory decisions in a Go/NoGo task: Response bias or memory bias? Cogn. Emot. 22, 761–776.
Yang, S., Luo, W., Zhu, X., Broster, L.S., Chen, T., Li, J., Luo, Y., 2014. Emotional content modulates response inhibition and perceptual processing. Psychophysiology 51, 1139–1146.
Yang, T., Yang, Z., Xu, G., Gao, D., Zhang, Z., Wang, H., Liu, S., Han, L., Zhu, Z., Tian, Y., Huang, Y., Zhao, L., Zhong, K., Shi, B., Li, J., Fu, S., Liang, P., Banissy, M.J., Sun, P., 2020. Tsinghua facial expression database - A database of facial expressions in Chinese young and older women and men: Development and validation. PLoS One 15, e0231304.
Yeung, M.K., Wan, J.C., Chan, M.M., Cheung, S.H., Sze, S.C., Siu, W.W., 2024. Motivation and emotional distraction interact and affect executive functions. BMC Psychol. 12, 188.
Young, M.E., Sutherland, S.C., McCoy, A.W., 2018. Optimal go/no-go ratios to maximize false alarms. Behav. Res. Methods 50, 1020–1029.
Yu, F., Zhu, C., Zhang, L., Chen, X., Li, D., Zhang, L., Ye, R., Dong, Y., Luo, Y., Hu, X., Wang, K., 2015. The neural substrates of response inhibition to negative information across explicit and implicit tasks in GAD patients: electrophysiological evidence from an ERP study. Front. Psychol. 6, 275.
Zhang, J., Feng, C., Mai, X., 2016. Automatic emotion regulation in response inhibition: The temporal dynamics of emotion counter-regulation during a go/no-go task. Psychophysiology 53, 1909–1917.
Zhang, M., Wang, S., Zhang, J., Jiao, C., Chen, Y., Chen, N., Zhao, Y., Wang, Y., Zhang, S., 2020. The Effects of Subliminal Goal Priming on Emotional Response Inhibition in Cases of Major Depression. Front. Psychol. 11, 542454.
Zhang, W., Lu, J., 2012. Time course of automatic emotion regulation during a facial Go/ Nogo task. Biol. Psychol. 89, 444–449.
Zhu, S., Liu, Q., Zhang, X., Zhou, M., Zhou, X., Ding, F., Zhang, R., Becker, B., Kendrick, K.M., Zhao, W., 2024. Transcutaneous auricular vagus nerve stimulation enhanced emotional inhibitory control via increasing intrinsic prefrontal couplings. Int. J. Clin. Health Psychol. 24, 100462.