When Arrows Behave Like Eyes: Reversal of Spatial Stroop Interference by Visual Masking

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Abstract

The Reversed Congruency Effect (RCE) typically observed with gaze targets has been rarely demonstrated with non-social stimuli like arrows targets. In a novel approach, we conducted two pre-registered experiments to investigate whether the RCE can be elicited using non-social stimuli (arrows) when directional information is visually masked. Participants performed a spatial Stroop task with arrows varying in perceptual complexity due to overlapping visual masks. Direction and spatial location were either congruent or incongruent. Remarkably, highly masked arrows elicited an RCE, with faster responses on incongruent trials. Distributional analyses showed reduced interference among the fastest responses and larger RCE in middle quantiles. Additionally, increased errors for both congruent and incongruent conditions were observed in the fastest responses, with congruent trials showing higher error rates, as previously observed with gaze targets. These findings suggest that the RCE reflects a dynamic interplay between early response capture and inhibitory control, shaped by the visual features of masked stimuli. Critically, they raise the possibility that similar perceptual constraints contribute to the RCE observed with gaze targets, offering a potential non-social mechanism underlying this effect. Our results highlight how visual complexity can modulate automatic activation and control processes, underscoring the value of distributional methods for revealing the temporal dynamics of interference.

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1. Introduction

Research on social attention often investigates whether gaze-driven orienting relies on general mechanisms for processing directional cues or on specialized processes for interpreting others' intentions (Apperly & Butterfill, 2009; Cole & Millett, 2019). However, standard cueing paradigms yield similar effects for arrows and gaze (Chacón-Candia et al., 2023), underscoring the need for more information methods. One possibility is the recently widely used spatial interference paradigm (Lu & Proctor, 1995), typically implemented using the spatial Stroop task (e.g., Cañadas & Lupiáñez, 2012; Marotta et al., 2018).

In this task, participants are asked to respond to the direction (left or right) indicated by a

lateralized target, such as an arrow or a gaze, while ignoring its spatial location (i.e., whether it appears to the left or right of fixation). Trials are considered congruent when the direction indicated by the stimulus matches its spatial location (e.g., a right-pointing arrow on the right side of fixation) and incongruent when it does not (e.g., a right-pointing arrow on the left side of fixation). Non-social stimuli, such as arrows, typically produce a standard congruency effect (SCE), characterized by faster responses on congruent than incongruent trials. In contrast, gaze stimuli often elicit a reversed congruency effect (RCE), with faster responses on incongruent trials (e.g., Hemmerich et al., 2022; Ishikawa et al., 2021).

The SCE is typically attributed to the asymmetric relationship between different stimulus dimensions, specifically, the task-relevant direction and the task-irrelevant spatial location relative to lateralized motor responses (Lu & Proctor, 1995; Viviani et al., 2024). According to Kornblum's (1992) taxonomy, this setup constitutes a Type 8 ensemble, characterized by Stimulus-Stimulus (S-S) and Stimulus-Response (S-R) dimensional overlap. Even when participants are explicitly instructed to focus on the relevant dimension (i.e., direction), spatial location still influences response selection and motor execution. This overlapping-dimensional interference suggests that conflict must be resolved at multiple levels such as task, stimulus, and response (Viviani et al., 2024).

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The specific dynamics underlying the SCE have been further explained within the dual-route processing framework (e.g., Ponce et al., 2025a, 2025b; Tanaka et al., 2024, 2025a). Although this framework has been predominantly applied to explain the dynamics of Simon and Simon-like tasks (S-R overlap, e.g., Luo & Proctor, 2017; Scerrati et al., 2017; Torres-Quesada et al., 2022), its assumptions extend to the spatial Stroop task.

According to the dual-route framework information is processed along two parallel routes (Cohen et al., 1990; De Jong et al., 1994; Luo & Proctor, 2017, 2019; Mittelstädt & Miller, 2020; Ridderinkhof, 2002a, 2002b; Ulrich et al., 2015): an automatic route that processes spatial information irrelevant to the task and a controlled route that processes task-relevant information (i.e., stimulus direction), based on the instructed S-R mapping (e.g., "Press the left-hand key if the stimulus is pointing or looking to the left"). On incongruent trials, these two routes activate competing responses. The automatic route may trigger a response based on where the stimulus appears (see automatic response capture, Torres-Quesada et al., 2022; van Campen et al., 2014; 2018), while the controlled route tries to guide the response based on its direction (Ridderinkhof, 2002a, 2002b; Ulrich et al., 2015). This conflict typically results in slower reaction times (RTs) and increased error rates.

However, the mechanisms underlying the RCE observed with gaze targets remain under debate. Several theoretical accounts have been proposed over time, emphasizing either a social component (Cañadas & Lupiáñez, 2012; Edwards et al., 2020; Marotta et al., 2018), stimulus perceivability (Chen et al., 2022), or difficulties in accessing task-relevant information (Tanaka et al., 2024, 2025a). Other accounts have aimed to integrate both perspectives within a unified framework, proposing that gaze might trigger general mechanisms shared with arrows, and additional social-specific mechanisms (Hemmerich

et al., 2022; Ponce et al., 2025a, 2025b; Román-Caballero et al., 2021a, 2021b). In other words, these accounts have proposed that social targets also trigger the cognitive mechanisms that lead to an SCE, but the final effect that is observed is reversed by the additional implication of social mechanisms.

Empirical research has explored the conditions under which the RCE emerges, providing important insights into the factors that shape this effect. It has been consistently observed with eye-gaze stimuli, whether presented as isolated eyes (Chacón-Candia et al., 2024; Ishikawa et al., 2021) or full-face targets (Cañadas & Lupiáñez, 2012; Hemmerich et al., 2022; Román-Caballero et al., 2021a). However, it does not appear with other directional stimuli like pointing hands or words (Bonventre & Marotta, 2023; Dalmaso et al., 2022; Hemmerich et al., 2022).

Interestingly, the RCE has also been observed with non-traditional cues, such as tongues (Tanaka et al., 2024), some animal faces (Ishikawa et al., 2024), inverted faces (Tanaka et al., 2023), and to a lesser extent with non-social targets (Román-Caballero et al., 2021a). These findings suggest that social meaning or stimulus familiarity may contribute to the effect but are not the only determining factors.

Developmental evidence supports the view that whereas the SCE is already shown by 4-year-old children the RCE emerges gradually with age. Aranda-Martín et al. (2022) found that, contrary to the effect observed in adult samples, gaze stimuli elicited an SCE in children under 12 years, whereas adolescents (12–17 years) already exhibited the usual reversed effect measured commonly in adults.

Hemmerich et al. (2022) observed the usual SCE for non-social stimuli, either arrows or words, and the opposite RCE for social stimuli, i.e., gaze (either cropped eyes or full faces). However, by analyzing the congruency sequence effect, they showed that both social and non-social stimuli

induced the same effect in the following trial. Thus, after both incongruent arrow trials and incongruent gaze trials, the same reduced standard congruency influence was observed, which manifested as an increase in the RCE for social stimuli, and a reduction in the SCE for non-social stimuli. Similarly, after both congruent arrow trials and congruent gaze trials, there was an increase in the standard congruency influence, manifested as a reduction in the RCE for social stimuli, and an increase in the SCE for non-social stimuli. Notably, this differential pattern emerged even when social and non-social stimuli were intermixed within the same experimental block.

Román-Caballero et al. (2021a, 2021b) showed that increasing the perceptual background complexity produced a similar effect, reducing the SCE for arrows and enhancing the RCE for gaze targets. In their study, arrows were presented against complex backgrounds to simulate the perceptual complexity of social stimuli, specifically eyes embedded in faces. They argued that the need to segregate the target from its background introduces a temporal delay in extracting task-relevant information. This delay allows the irrelevant spatial code to decay (*temporal-delay* hypothesis; Hommel, 1993), thereby reducing spatial conflict. When the perceptual salience of the directional information was increased by presenting the target alone after the background a larger SCE (and a reduced RCE) was observed. However, for eyes alone or embedded in faces, the RCE remained robust across experiments.

Neurophysiological findings further support the distinction between non-social and social mechanisms underlying the effect observed for social targets. Marotta et al. (2019) found that both social and non-social stimuli elicited similar early event-related potential components (P1 and N1) but diverged at later stages (N2 and P3), suggesting commonalities and differences in conflict resolution processes. Complementary functional magnetic

resonance results showed overlapping activation in right parieto-temporo-occipital regions for both arrow and gaze stimuli during conflict resolution, along with distinct activation patterns in the frontal eye field and occipital regions (Narganes-Pineda et al., 2023).

Thus, whereas a general spatial conflict mechanism might be common for social and non-social targets, an additional social mechanism may be induced by social targets, with socially oriented hypotheses proposing these two mechanisms to be distinct. The eye-contact hypothesis proposes that incongruent gaze stimuli (e.g., a left looking gaze presented at the right) are perceived as "looking at" the participants, thereby facilitating responses (Cañadas & Lupiáñez, 2012; Marotta et al., 2018; Ponce et al., 2025a). The joint attention hypothesis posits that incongruent trials align participants' attention with the stimulus direction (joining attention at fixation), thus enhancing response speed (Edwards et al., 2020). Conversely, the joint distraction hypothesis (Hemmerich et al., 2022) suggests that congruent gaze cues (e.g., a left looking gaze presented at the right) may automatically divert attention away from the task space, making it necessary to reorient attention back to the relevant task area, thus slowing RTs.

Support for the social nature of the additional mechanism triggered by social targets includes findings that the RCE is modulated by facial emotion (Jones, 2015; Marotta et al., 2022; Torres-Marín et al., 2017), it is negatively correlated with social anxiety scores for gaze targets but not arrows or words (Ishikawa et al., 2021), and it is influenced by stimulus familiarity (Ishikawa et al., 2024). However, these interpretations have been challenged. Narganes-Pineda et al. (2022) showed that explicit processing of stimulus direction was necessary to elicit the RCE, contradicting the automaticity assumed by the eye-contact hypothesis. The developmental results from Aranda-Martín et al. (2022) also raise questions about the

sufficiency of joint attention mechanisms in explaining the RCE, since such mechanisms emerge before age four (Mundy et al., 2007). Additionally, Aranda-Martín et al. (2023) found that adding external objects or frames to reduce distraction in congruent trials did not diminish the RCE, challenging the joint distraction account.

This has led some authors to question the social nature of the additional mechanisms reversing the SCE, by arguing that the RCE might not require any social processing and could rather be explained by perceptual or task-related dynamics alone. For instance, Chen et al. (2022) found that stimuli with similar perceptual features elicited comparable congruency effects regardless of their social nature. When perceptually simplified, both gaze and arrow stimuli produced an SCE (Experiment 3), whereas more complex stimuli (Experiment 2) showed no significant difference between social and non-social targets, suggesting that stimulus perceivability plays a key role (although see Cañadas & Lupiáñez, 2012).

Tanaka et al. (2024) observed an RCE using tongues as directional stimuli and proposed the dual-stage hypothesis, based on the activation-suppression framework (Ridderinkhof, 2002a, 2002b). According to this model, in the first stage, background segregation delays access to task-relevant information, allowing irrelevant spatial codes to decay (Román-Caballero et al., 2021a; 2021b). In the second stage, selective inhibition acts on the remaining spatial code. If the spatial and directional codes are congruent, inhibition may suppress the correct response, delaying it. In contrast, during incongruent trials, inhibition suppresses the incorrect response code, facilitating the correct response. With simple stimuli like arrows, this mechanism may not engage quickly enough, resulting in the typical SCE. However, if directional information is sufficiently delayed or inhibition strongly activated, even arrows might elicit an RCE.

Nevertheless, it remains unclear whether perceptual difficulty alone is sufficient to produce the RCE. While some studies have shown the RCE with non-social stimuli, its magnitude tends to be smaller and less consistent than the RCE observed with gaze (Román-Caballero et al., 2021a; Tanaka et al., 2025a). In addition, some of those studies used mosaic patterns derived from faces, which might still trigger face-specific processing. As such, the role of perceptual complexity alone in generating the RCE has not been directly tested.

Interestingly, the RCEs elicited by non-social stimuli appear to differ in important ways from those elicited by social stimuli. This difference can be seen from a detailed examination of the temporal dynamics underlying location-based conflict effects (Ponce et al., 2025a, 2025b; Tanaka et al., 2025a, 2025b). Using the conditional accuracy function (CAF), a method that links accuracy to response speed (Heitz, 2014), recent studies have shown that among the fastest responses social stimuli not only lead to lower accuracy for both congruent and incongruent trials, but also elicit a reversal pattern, with more errors on congruent than incongruent trials (Ponce et al., 2025a).

This effect was especially pronounced for full-face and emotional face stimuli, suggesting that beyond the typical response capture driven by task-irrelevant spatial location (as seen with non-social stimuli; Torres-Quesada et al., 2022; Ridderinkhof, 2002a, 2002b; van Campen et al., 2014, 2018), social targets may activate distinct cognitive mechanisms that modulate early processing stages.

Delta function analyses, which assess how the spatial Stroop effect varies across response latencies (De Jong et al., 1994; Pratte et al., 2010; Speckman et al., 2008), have also shown a distinctive pattern of RCE dynamics in response to social stimuli. The RCE remains consistent from the second quantile onward in a five-point delta function (Ponce et al., 2025b), and across the entire distribution in a four-point delta function (Tanaka et al., 2025a). In

contrast, for non-social targets embedded in complex backgrounds, the reversal tends to emerge only in the slower portions of the distribution and with a smaller magnitude (Tanaka et al., 2025a). These findings suggest that gaze stimuli, whether isolated eyes or full-face images, may elicit specific patterns either due to their social nature or their perceptual complexity and configuration.

The present pre-registered study investigated whether the RCE is primarily driven by domain-specific social mechanisms or can also arise from task-related factors, such as difficulty in accessing task-relevant information due to increased visual complexity. Previous research has shown that non-social stimuli can occasionally elicit small RCEs, though typically with weaker and less consistent patterns than those found with social stimuli. Building on these findings, we pre-registered the hypothesis that greater difficulty would weaken the SCE, while additional social features are necessary to fully reverse it (see **Section 2.1.5.**).

To test this hypothesis, we first examined whether a reversal of the spatial Stroop effect could be elicited by perceptual complexity alone, in the absence of social content. Building on Román-Caballero et al. (2021a, 2021b) and Tanaka et al. (2024, 2025a), we manipulated the ease of processing directional information in non-social stimuli (arrows) by overlaying them with different levels of visual noise using overlapping oblique lines acting as a mask, creating three degrees of difficulty (**Figure 1**). This masking manipulation, conceptually related to techniques used in masked priming studies that often yield the negative compatibility effect (e.g., Eimer & Schlaghecken, 2002), was intended to hinder access to directional information without introducing social features.

We predicted that increasing perceptual difficulty would lead to a gradual reduction in the SCE. However, a full reversal (i.e., an RCE) would only occur with social stimuli. In contrast, if a clear RCE were to be observed with increased perceptual

difficulty for non-social stimuli, the social nature of the mechanism producing the RCE observed with gaze would be called into question.

In addition, we examined the temporal dynamics of interference using two distributional analyses: CAF and delta plots. Prior research has shown that increasing perceptual demands, such as through reduced visibility (Mittelstädt & Miller, 2020), added conflicting layers (Scerrati et al., 2017), or decreased discriminability (Ellinghaus et al., 2024), can modulate interference in location-based conflict tasks. Accordingly, we expected to observe changes in conflict dynamics, but not the early accuracy reversal or full RCE typically associated with social stimuli.

2. Experiment 1

In Experiment 1, we aimed to investigate whether hindering access to task-relevant directional information is sufficient to reduce or eliminate spatial interference, even when using only non-social stimuli (i.e., arrows). To do so, we manipulated perceptual difficulty by masking arrow stimuli with several oblique lines (see **Figure 1**), creating three levels of difficulty. This masking technique was intended to impede the extraction of arrow direction, without introducing background complexity or social content.

For level-1 stimuli, we expected to observe the SCE, as the irrelevant information still impacts on the processing of the relevant directional information. For level-2 stimuli, we predicted a reduction in the SCE compared to level-1, as increased visual noise would hinder directional processing and allow spatial codes to decay or be inhibited. Finally, for level-3 arrows, we expected that spatial interference would be eliminated as task-irrelevant spatial codes should decay or be fully inhibited before response selection.

In the CAF analysis, we expected the typical pattern for level-1 arrows: lower accuracy rates for incongruent trials in the fastest responses, and stable accuracy for congruent trials across the distribution. For level-2 and level-3 arrows, we anticipated an overall reduction in accuracy, particularly in the fastest responses, and no congruency difference in accuracy reflecting increased difficulty in extracting relevant directional information.

In the delta plots analysis, we expected a stronger SCE in the fastest responses, reflecting early interference from irrelevant information that gradually decays or is inhibited over time. For level-2 and level-3 arrows, we expected a similar pattern, larger SCE in the fastest responses, followed by a reduction approaching zero at slower RTs.

2.1.   Method

2.1.1. Participants

Thirty-four adults (22 females; mean age = 22.4 years, *SD* = 2.9) participated in the study. All were students from the University of Granada who signed an informed consent form. Participants were able to choose between receiving 6 euros or partial course credit for their participation and were naïve to the purpose of the experiment. Data collection took place in June 2024. The study was conducted in accordance with the ethical guidelines of the University of Granada (3232/CEIH/2023) and the 1964 Declaration of Helsinki. Outliers were identified based on mean accuracy scores, with participants excluded if their overall performance fell more than 3 standard deviations below the group mean across conditions.

Sample size was a priori computed based on power analyses conducted using data from Marotta et al. (2018), applying the *Superpower* R package (Lakens & Caldwell, 2021), which enables simulation-based planning for ANOVA designs. Based on data from non-social targets, we ran simulations (10,000 iterations each) to test for the interaction between target type (three levels) and congruency (two levels), aligned with our expected effects (the script

and dataset are available in OSF, see **Section 2.1.5.**). With a sample size of 34 and α set at .05, the simulation yielded a power of .81 to detect an effect size of Cohen's f = 0.16. Additionally, we conducted a separate power analysis for the congruency effect using arrow stimuli via the *pwr* R package (Champely et al., 2022). With N = 34, α = .05, and an expected effect size d_z = 0.71, the analysis yielded a power of .99 for a one-sided paired t-test. However, for all statistical analyses, including congruency effects for any target type, we employed two-tailed tests to ensure consistency and adopt a more conservative approach, particularly given prior evidence that non-

social stimuli can also elicit RCEs (Román-Caballero et al., 2021a; Tanaka et al., 2025a).

2.1.2. Apparatus and Stimuli

The study was conducted online. The experiment was programmed using *OpenSesame* (Mathot et al., 2012) and administered via *JATOS* (Lange et al., 2015). Arrow stimuli were presented with oblique lines that served as a mask to reduce their perceptual clarity, producing three levels of difficulty (**Figure 1**). To control for any inadvertent directional biases associated with the lines, each mask configuration was also presented in a mirrored version.

Figure 1.

Masked Arrows Example
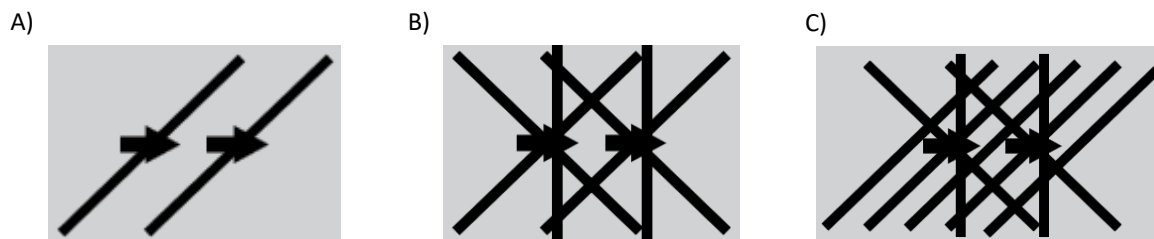
Note. Examples of target types with three levels of perceptual difficulty: (A) level-1, (B) level-2, and (C) level-3.

2.1.3. Procedure

The procedure was adopted from Marotta et al. (2018). Participants first completed 15 practice trials, followed by two experimental blocks of 192 trials each. All three levels of target difficulty were randomly intermixed within each block. Each block included 64 congruent and 64 incongruent trials per target type, yielding a total of 384 experimental trials.

Participants performed a spatial Stroop task in which they were instructed to respond as quickly and accurately as possible to the direction of the arrow (left or right) while ignoring its spatial location. Each trial began with a central fixation cross (1000 ms), followed by the lateralized arrow target (pointing left or right), which remained onscreen until a response was made or for a maximum of 2000

ms (**Figure 2**). Incorrect responses were followed by auditory feedback lasting 1500 ms.

Figure 2

Schematic View of a Trial Sequence
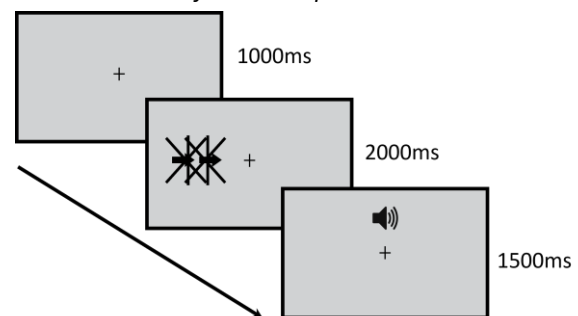
Note. The example represents incongruent trials of the target type level 2. The speaker icon represents the auditory feedback that is provided on incorrect responses.

Participants were instructed to fixate on the central cross and to respond using the "C" key for

left-pointing arrows and the "M" key for right-pointing arrows, regardless of the stimulus location.

2.1.4. Design and Statistical Analysis

The study employed a 3 × 2 within-subjects design with two factors: target type (level-1, level-2, level-3 arrows) and congruency (congruent vs. incongruent). Repeated-measures ANOVAs tested the two main effects and their interaction for both RT and accuracy. Given a significant interaction, we conducted paired two-tailed t-tests comparing congruent and incongruent trials within each target type (Bonferroni-corrected). As preregistered, we also computed spatial interference effects (incongruent minus congruent RTs), which were tested against zero and compared across target types.

Conditional Accuracy Function (CAF) analyses were conducted to explore temporal dynamics in performance. RTs were sorted from fastest to slowest and divided into five equal-sized bins (20% each), following procedures from previous studies (e.g., Hübner & Töbel, 2019; Ponce et al., 2025a). Accuracy was calculated per participant within each combination of target type, congruency, and bin, yielding a 3 × 2 × 5 repeated-measures design. Delta function analyses were performed on correct responses using quantile averaging (Ratcliff, 1979). RT quantiles were estimated using R's quantile function with the type 8 estimator (Hyndman & Fan, 1996) at the following probabilities: .1, .3, .5, .7, and .9 (e.g., Grange, 2016; Ponce et al., 2025b). Delta values were calculated as the difference between RTs on incongruent and congruent trials at each quantile. This yielded a 3 × 5 design (target type × quantile). For both CAF and delta function analyses, repeated-measures ANOVAs tested for main effects and interactions. Additional

paired t-tests (Bonferroni-corrected) compared congruency levels within each CAF bin by target type and assessed differences in delta values across target types and quantiles. One-sample t-tests were also used to determine whether delta values at each quantile significantly differed from zero.

2.1.5. Transparency and Openness

We reported how we determined our sample size, all data exclusions, manipulations, and measures. All hypotheses, experimental design, and analysis plans were preregistered prior to data collection. The preregistrations, along with task materials, stimuli, datasets, and analysis scripts, are publicly available on the Open Science Framework (OSF) at https://osf.io/yvcak/.

2.2.   Results and Discussion

Practice trials were excluded from all analyses. Following the procedure used by Marotta et al. (2018), trials with RTs below 200ms (0.05%) or above 1300 ms (1.86%), together with incorrect responses (5.30%), were excluded from the RT analysis. The same trimming procedure was applied to the distributional analyses. Greenhouse–Geisser (GG) corrections were applied when the assumption of sphericity was violated. **Table 1** shows mean RTs and percentage of incorrect responses by condition.

2.2.1. Reaction Time

The ANOVA on RTs revealed a main effect of target type, $F(1.55, 51.11) = 115.04$, $p < .001$, $\eta_p^2 = .78$. Participants responded fastest to level-1 arrows (558 ms), followed by level-2 (596 ms), and level-3 arrows (626 ms). All pairwise comparisons between the three levels were significant (all ps < .050).

Table 1.

Mean RT in Milliseconds and Percentages of Incorrect Responses (IR) by Condition and Experiment

| | | Experiment 1 | | Experiment 2 | | | |
| | | | | within | | between | |
		congruent	incongruent	congruent	incongruent	congruent	incongruent
Arrows Level1	RT	547 (79)	569 (88)	557 (106)	571 (106)	517 (87)	547 (101)
	% IR	1.11 (1.42)	4.16 (5.52)	2.21 (2.73)	4.81 (4.69)	3.13 (3.06)	8.24 (6.19)
Arrows Level2	RT	603 (69)	588 (84)	616 (104)	596 (110)	587 (73)	570 (81)
	% IR	5.85 (6.62)	4.53 (5.94)	7.68 (5.34)	6.84 (6.50)	7.42 (6.59)	6.25 (6.91)
Arrows Level3	RT	633 (77)	619 (81)	641 (100)	621 (105)	607 (76)	588 (76)
	% IR	6.68 (9.56)	5.53 (6.04)	11.17 (8.54)	8.01 (6.60)	8.72 (8.09)	6.25 (6.22)
Gaze	RT	-	-	646 (105)	626 (109)	582 (91)	578 (96)
	%IR	-	-	5.44 (4.99)	5.34 (5.53)	4.33 (4.57)	7.26 (7.42)

Note. Standard deviations of RTs and IRs are reported in parentheses.

Figure 3

Mean RTs by Congruency for Each Target Type
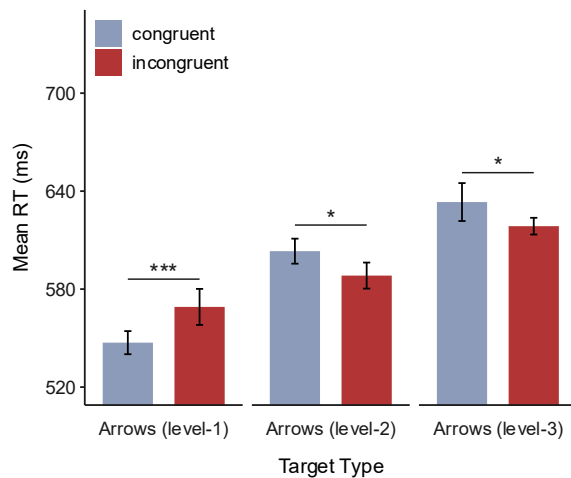
Note. Blue-purple bars correspond to congruent trials and red bars to incongruent trials. Error bars represent 95% confidence intervals, adjusted using the Cousineau-Morey method (Morey, 2008). Asterisks indicate significance levels: *p < .05, **p < .01, *** p < .001.

Critically, there was a significant interaction between target type and congruency, $F(2, 66)$ = 22.23, p < .001, η_p^2 = .40. Follow-up analyses revealed an SCE for level-1 arrows, $t(33)$ = −3.84, p < .001, d_z = −0.66, with faster responses in congruent than incongruent trials, and an RCE for both level-2,

$t(33)$ = 2.47, p = .019, d_z = 0.42, and level-3 arrows, $t(33)$ = 2.53, p = .016, d_z = 0.43, with faster responses for incongruent than congruent trials (**Figure 3**). The congruency effect did not differ significantly between level-2 (−15 ms) and level-3 (−15 ms) arrows, but both differed significantly from level-1 arrows (22 ms; see **Supplemental Material**).

2.2.2. Accuracy

The accuracy analysis revealed a main effect of target type, $F(2, 66)$ = 10.04, p < .001, η_p^2 = .23. Error rates were lower for level-1 arrows (2.63%) than for level-2 (5.19%) and level-3 (6.11%) arrows, with no significant differences between the latter two.

The interaction between target type and congruency was also significant, $F(1.65, 54.45)$ = 7.20, p = .003, η_p^2 = .18. Pairwise comparisons revealed that level-1 arrows elicited fewer errors on congruent than on incongruent trials (**Table 1**), $t(33)$ = 3.08, p = .004, d_z = 0.53. No other congruency effects reached significance.

2.2.3. Distribution Analysis

CAF analyses revealed a significant three-way interaction among target type, congruency, and bin, $F(3.70, 122.08) = 3.02$, $p = .023$, $\eta_p^2 = .08$. For the fastest RT bin, only level-1 arrows showed a congruency effect, $t(33) = 2.97$, $p = .006$, $d_z = 0.51$, with more errors on incongruent than congruent trials. Additionally, for level-1 arrows, accuracy in the first bin was lower than in bins two and three. Although the differences between congruent and incongruent trials reversed in sign (i.e., more errors for congruent than incongruent trials) for level-2 and level-3 arrows, these differences were not significant. However, both the level-2 and level-3 conditions showed reduced accuracy in the first bin, regardless of congruency, compared to later bins (**Figure 4A**).
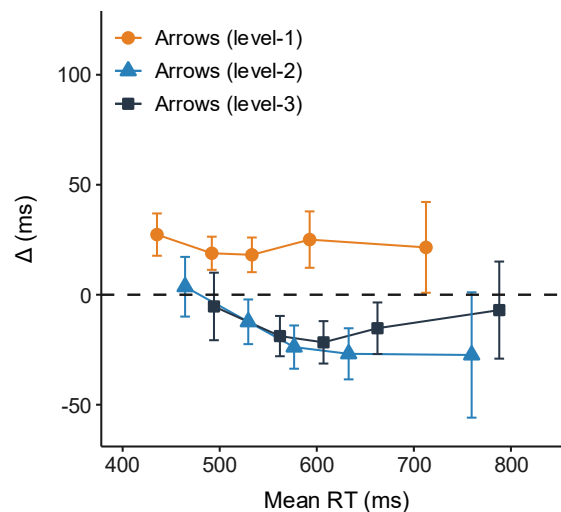
Figure 4

Distributional Analysis from Experiment 1
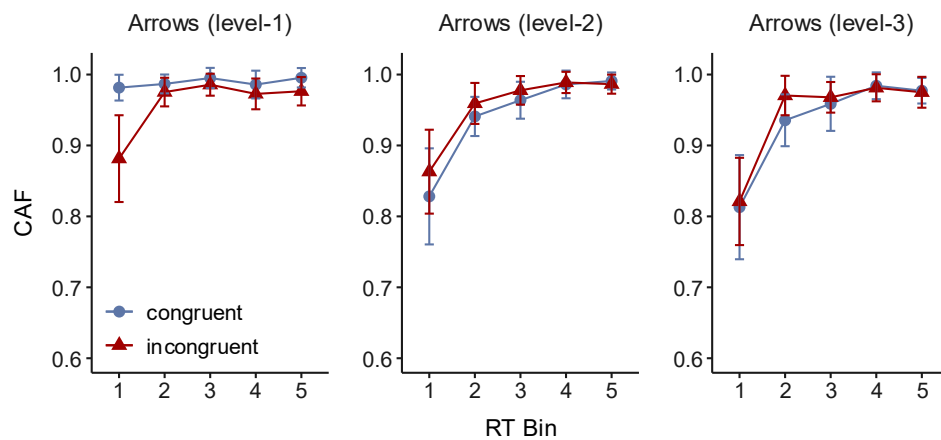
A)

B)

Note. Panel (A) shows CAFs (accuracy across RT bins for congruent and incongruent trials, by target type). Blue-purple points indicate congruent trials, and red triangles indicate incongruent trials. Panel (B) shows delta plots (RT differences between incongruent and congruent trials across mean RT quantiles). Orange circles represent level-1 arrows, light-blue triangles level-2 arrows, and dark-blue squares level-3 arrows. Error bars represent 95% confidence intervals, adjusted using the Cousineau–Morey method (Morey, 2008).

Delta function analysis revealed a main effect of target type, $F(2.00, 66.0) = 20.15$, $p < .001$, $\eta_p^2 = .38$. Planned one-sample t-tests against zero showed that level-1 arrows exhibited an SCE across the RT distribution, with the exception of the fifth quantile ($p = 0.058$). In contrast, the RCE for level-2 and level-3 arrows emerged primarily in the mid-range quantiles: the third and fourth quantiles for level-2 arrows and the second and third quantiles for level-3 arrows (**Figure 4B**). The remaining quantiles did not significantly differ from zero. Additionally, the RCE increased across quantiles only for level-2 arrows, peaking at the third quantile (i.e., larger effect at the third compared to the first quantile); no other quantile-related effects were observed for the remaining target types.

2.2.4. Discussion

Experiment 1 investigated whether increased perceptual difficulty in non-social stimuli (i.e., arrows) could modulate or reverse the spatial congruency effect (SCE), commonly observed in location-based conflict tasks. The results provide compelling evidence that, contrary to our hypotheses, the perceptual manipulation alone—without social content—can significantly alter the direction of congruency effects, including the emergence of a reversed congruency effect (RCE). As predicted, level-1 arrows elicited a robust SCE, with faster and more accurate responses in congruent compared to incongruent trials. This pattern replicates the classical Stroop effect generally observed in spatial interference tasks. In contrast, level-2 and level-3 arrows revealed a significant RCE with participants responding faster to incongruent than congruent trials. This finding challenges our initial hypothesis that a social component is necessary to elicit the RCE and supports the view that hindering the processing of task-relevant information can be enough to produce the effect.

Distributional analyses further confirmed this interpretation. CAF plots revealed that the SCE in level-1 arrows was strongest among the fastest responses, consistent with early response capture by irrelevant spatial information. For level-2 and level-3 arrows, the CAF analyses showed reduced accuracy in the fastest bin for both congruent and incongruent trials, consistent with prior findings with social stimuli (Ponce et al., 2025a). However, in contrast to what usually happens with gaze targets, no clear reversal in accuracy was observed within the first bins. Overall, the pattern suggests that increased perceptual complexity interferes with early information extraction.

Delta function analyses reinforce this interpretation: while level-1 arrows exhibited a SCE across most of the RT distribution, levels 2 and 3 showed an RCE that peaked in the mid-range quantiles. Notably, no SCE appeared for levels 2 and 3 at any point across the distribution, contrasting with previous studies using complex backgrounds to induce RCEs in non-social targets (Tanaka et al., 2025a). These results suggest that the RCE observed with masked arrows might be more robust than that induced by background complexity.

Overall, our findings show that while social targets may modulate the magnitude and pattern of the RCE (Ponce et al., 2025b; Tanaka et al., 2025a), they are not essential for its emergence. Simply increasing perceptual noise that impairs access to directional information seems sufficient to produce an RCE, supporting non-social accounts (Tanaka et al., 2024, 2025a). However, the conflict effects and dynamics of the RCE may differ between social and non-social targets. We directly compared these in the next experiment.

An alternative possibility is that the RCE elicited by masked arrows may reflect not just perceptual difficulty, but a global strategic adjustment adopted by participants in response to how the task was structured (Ellinghaus et al., 2024; Hübner & Mishra, 2013). Prior research has shown that people can adapt their cognitive control depending on task demands and expectations (Banich, 2019; Braver, 2012; Spinelli et al., 2022). For

instance, Hübner and Mishra (2013) proposed that participants modulated the suppression of task-irrelevant information (i.e., location of the stimuli) depending on predictability. When task conditions varied unpredictably (i.e., randomized blocks), stronger suppression is required to maintain performance, resulting in smaller interference effects. In contrast, under more predictable conditions (i.e., blocked designs), less suppression is sufficient to achieve comparable performance.

In Experiment 1, all levels of stimulus perceptual difficulty were randomly intermixed within the same block. This unpredictability may have encouraged participants to adopt a global suppression strategy, reducing the influence of irrelevant location information. Such a strategy could have contributed to the RCE, alongside the effects of perceptual masking. Notably, strategic adaptation and perceptual complexity explanations are not mutually exclusive. However, to better understand the role of perceptual complexity, it is necessary to test whether it alone can produce the RCE, independent of strategic factors.

3. Experiment 2

The goal of Experiment 2, also preregistered (see **Section 3.1.5.**), was to test the robustness of the results from Experiment 1 and to directly compare spatial interference effects elicited by arrow and gaze stimuli. Additionally, following the rationale of Hübner and Mishra (2013), we manipulated stimulus predictability to examine whether participants adjust their inhibitory strategies based on the consistency of target presentation. To this end, we included both masked arrow targets as in Experiment 1, as well as gaze targets, and assigned participants to one of two experimental groups: (1) a within-block group in which all target types (level-1 arrows, level-2 arrows, level-3 arrows, and gaze) were intermixed (as in Experiment 1), and (2) a between-block group, in which each target type was presented in separate blocks.

Considering the pattern of results observed in Experiment 1, we pre-registered the hypothesis that level-1 arrows would elicit an SCE, while level-2 and level-3 arrows, as well as gaze stimuli, would produce an RCE. Moreover, we expected these effects to interact with stimulus presentation sequence. In the within-block condition, where target type is less predictable, we anticipated stronger suppression of irrelevant location codes, leading to reduced SCEs and enhanced RCEs (Román-Caballero et al., 2021a, 2021b). Conversely, in the between-block condition, reduced suppression was expected to yield larger SCEs and diminished RCEs.

At the distributional level, we expected the within-block group to replicate the pattern observed in Experiment 1. In contrast, the between-block group was expected to show larger SCEs (i.e., weaker suppression) and a reduced RCE, particularly in the earliest response bins of the CAF, where such modulations typically emerge (Ponce et al., 2025a), and across the response distribution in the delta plots.

3.1.   Method

3.1.1.   Participants

Ninety-six participants took part in the study, with 48 randomly assigned to each group. The within-block group included 46 females (mean age = 20.3, *SD* = 2.4), and the between-block group included 43 females (mean age = 20.6, *SD* = 2.7). All participants were undergraduate students at the University of Granada and received partial course credit for their involvement. Data collection took place between October and November 2024. The study adhered to the same ethical standards as Experiment 1. Participants with mean accuracy more than 3 SDs below the group mean were excluded as outliers.

The sample size was a priori determined to allow full counterbalancing in the between-block

condition. With four target types, block-order counterbalancing required 24 sequences, each assigned to two participants. A power analysis was conducted based on data from Román-Caballero et al. (2021a, Experiment 1), which reported a relatively small RCE for arrows presented against complex backgrounds. Using the *Superpower* R package (Lakens & Caldwell, 2021), we simulated 10000 iterations to estimate the power for the interaction between target type and congruency. Results indicated that a sample size of 35 participants would yield .80 power to detect a medium effect (Cohen's f = 0.20, α = .05). With 48 participants per group, our estimated power increased to .91. The full analysis script and dataset are available via OSF.

3.1.2. Apparatus and Stimuli

The experiment was conducted online using *JATOS* (Lange et al., 2015) and programmed in *OpenSesame* (Mathot et al., 2021). The task structure was identical to Experiment 1, with the addition of social stimuli and the group division (within block vs. between-block). Gaze targets consisted of color photographs of four female and four male faces with neutral expression, looking either left or right. Images were taken from the Karonliska Directed Emotional Faces database (Lundqvist et al., 1998), the same source used in Marotta et al. (2022). Each gaze stimulus was cropped into a rectangular frame, with the eyes horizontally centered and vertically aligned to match the position of the arrows and overlapping lines (**Figure 5**).

Figure 5

Masked Arrows and Gaze Stimuli

Note. Examples of (A) level-3 arrow stimuli and (B) gaze stimuli.

3.1.3. Procedure

The structure and number of trials by condition were identical to those used in Experiment 1, with the exception that this experiment was divided into four blocks separated by brief breaks. In the between-block group, each block presented a single target type, and block order was counterbalanced across participants. In the within-block group, all target types were randomly intermixed within each block.

3.1.4. Design and Statistical Analysis

Experiment 2 employed a 2 × 4 × 2 mixed design, with group (within-block vs. between-block) as the between-subjects factor, and target type (level-1 vs. level-2 vs. level-3 vs. gaze) and congruency (congruent vs. incongruent) as within-subject factors. Trimming procedures were the same as those used in Experiment 1. Distributional analyses (CAF and delta functions) were conducted using the same approach as in Experiment 1, with the addition of the group factor.

For the sake of clarity, only the results relevant to our primary research questions are reported below. Additional preregistered analyses are provided in the **Supplemental Material**.

3.1.5. Transparency and Openness

Transparency and openness procedures were identical to those in Experiment 1 (see https://osf.io/yvcak/ for all preregistrations, materials, data scripts analysis).

3.2. Results and Discussion

Trimmed responses were excluded from the RT and distributional analyses. In the within-block group, 0.10% of trials were faster than 200 ms and 2.55% were slower than 1300 ms. In the between-block group, 0.10% of trials were also faster than 200 ms, with 1.16% slower than 1300 ms. Incorrect responses were excluded from the RT analyses:

6.44% for the within-block group and 6.45% for the between-block group (**Table 1**).

3.2.1. Reaction Time

A significant main effect of target type was observed, $F(3, 282) = 115.81$, $p < .001$, $\eta_p^2 = .55$. Although responses to level-3 arrows (615 ms) and gaze stimuli (608 ms) did not significantly differ, both were slower than responses to level-2 arrows (592 ms) and level-1 arrows (548 ms), with level-2 arrows also significantly slower than level-1 arrows. The main effect of group was also significant, $F(1, 94) = 4.02$, $p = .048$, $\eta_p^2 = .04$, with slower overall responses in the within-block group (609 ms) compared to the between-block group (572 ms). This group difference was further evident in a significant group × target type interaction, $F(3, 282) = 5.20$, $p = .002$, $\eta_p^2 = .05$. Follow-up analyses showed that within-block participants responded more slowly than between-block participants for all target types. Moreover, pairwise comparisons within each group showed that in the within-block group, RTs increased from level-1 to level-2 and level-3 arrows, with gaze stimuli not differing from level-3 arrows but slower than level-1 and level-2. In the between-block group, a similar stepwise increase was observed, but here gaze stimuli were significantly faster than level-3 arrows and did not differ from level-2 arrows.
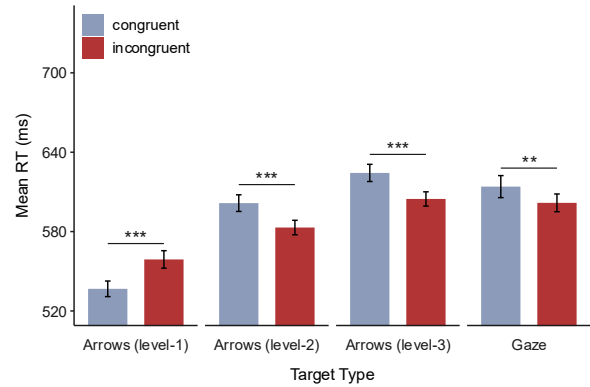
The three-way interaction between group, target type, and congruency was not significant, $F(3, 282) = 1.90$, $p = .129$, $\eta_p^2 = .02$. However, and more importantly. a significant target type × congruency interaction emerged, $F(3, 282) = 42.30$, $p < .001$, $\eta_p^2 = .31$. Consequently, the contrast analyses reported below were conducted across groups.

Replicating the pattern observed in Experiment 1, level-1 arrows elicited an SCE, with faster responses on congruent than incongruent trials (**Figure 6**), $t(95) = -6.78$, $p < .001$, $d_z = -0.69$. In contrast, level-2 and level-3 arrows produced an RCE, $t(95) = 5.36$, $p < .001$, $d_z = 0.55$, $t(95) = 6.37$, $p <$

.001, $d_z = 0.65$, respectively. Gaze stimuli also elicited a significant RCE, $t(95) = 2.84$, $p = .006$, $d_z = 0.29$.

Figure 6

Mean RTs (in milliseconds) by congruency for each target type

Note. As the interaction between group, target type, and congruency was not significant data were collapsed across groups for visualization purposes. Blue-purple bars correspond to congruent trials and red bars to incongruent trials. Error bars represent 95% confidence intervals, adjusted using the Cousineau–Morey method (Morey, 2008). Asterisks indicate significance levels: *p < .05, **p < .01, *** p < .001.

Regarding the spatial Stroop effect, analyses of Stroop interference scores showed that the group × target type interaction was not significant. However, both the main effect of group and the main effect of target type were significant. Consistent with our hypothesis, the within-block group showed a larger RCE (−12 ms) than the between-block group (−2 ms). Notably, the RCEs for level-2 arrows (−18 ms), level-3 arrows (−20 ms), and gaze targets (−12 ms) did not significantly differ from one another (although see **Supplemental Material** for results on gaze targets when analyzed separately by group), but all significantly differed from the SCE observed for level-1 arrows (22 ms).

3.2.2. Accuracy

A significant main effect of target type was observed, $F(2.55, 239.24) = 29.67$, p < .001, $\eta_p^2 = .24$. Error rates were lowest for level-1 arrows (4.60%), followed by gaze (5.59%), level-2 arrows (7.05%), and level-3 arrows (8.54%). Gaze stimuli did not significantly differ from level-1 arrows but showed

significantly lower error rates than level-2 and level-3 arrows. A significant interaction between group and target type was also found, $F(2.55, 239.24) = 7.89$, $p < .001$, $\eta_p^2 = .08$, driven by reduced error rates for level-1 arrows in the within-block group.

The three-way interaction between group, target type, and congruency was not significant. However, the interaction between target type and congruency was significant, $F(2.76, 259.33) = 25.09$, $p < .001$, $\eta_p^2 = .21$. Pairwise comparisons revealed that level-1 arrows elicited fewer errors on congruent (2.67%) than incongruent trials (6.53%), $t(95) = 7.57$, $p < .001$, $d_z = 0.77$. In a similar direction, gaze reached a marginal significant result, $t(95) = 1.98$, $p = .050$, $d_z = 0.20$, with fewer errors on congruent (4.88%) than incongruent trials (6.30%). In contrast, level-3 arrows showed the opposite pattern, with fewer errors on incongruent (7.13%) than on congruent trials (9.94%), $t(95) = -3.75$, $p < .001$, $d_z = -0.38$.

3.2.3. Distribution Analysis

Interestingly, the CAF analyses revealed a significant four-way interaction between group, target type, congruency and bin (**Figure 7A**), $F(6.10, 573.27) = 3.25$, $p = .004$, $\eta_p^2 = .03$. Follow-up analyses showed that level-1 arrows elicited the typical pattern in the fastest responses, with lower accuracy on incongruent than congruent trials in both the within-block group, $t(47) = 3.57$, $p < .001$, $d_z = 0.52$, and between-block group, $t(47) = 2.97$, $p < .001$, $d_z = 1.02$. The between-block group showed a larger congruency effect at this portion of the distribution, as indicated by the Cohen's d values. The RCE was observed in bin 2 for level-2 arrows in the within-block group, $t(47) = -3.40$, $p = .001$, $d_z = -0.49$, and for level-3 arrows in both the within-block group, $t(47) = -3.49$, $p = .001$, $d_z = -0.50$, and between-block group, $t(47) = -2.98$, $p = .005$, $d_z = -0.43$. Notably, gaze targets elicited an SCE in the first bin for the between-block group, $t(47) = 3.59$, $p < .001$, $d_z =$

0.52, and an RCE in the third bin for the within-block group, $t(47) = -2.20$, $p = .033$, $d_z = -0.32$.

Across bins, level-1 arrows showed reduced accuracy on incongruent trials in the first bin, especially in the between-block group. In contrast, replicating Experiment 1, level-2 and level-3 arrows showed reduced accuracy for both congruent and incongruent trials in the fastest responses. Gaze targets displayed a similar but weaker pattern, with lower accuracy in the first bin for both congruent and incongruent trials in both groups.

Delta function analysis revealed no significant three-way interaction but did show a significant two-way interaction between target type and quantile (**Figure 7B**), $F(5.34, 501.70) = 5.19$, $p < .001$, $\eta_p^2 = .05$. Further analyses indicated that level-1 arrows elicited an SCE across the entire distribution. Both level-2 and level-3 arrows consistently produced an RCE across quantiles, although the effect was attenuated in the first quantile, where level-2 arrows showed no significant difference against zero. Conversely, gaze stimuli, elicited an SCE in the first quantile, with the RCE emerging from the third to the fifth quantile.

In addition, to control for potential changes in conflict strength over time or due to block order, we performed complementary analyses on block structure (**Supplemental Material**). In the within-block group, a repeated-measures ANOVA with block (1–4) and target type as within-subject factors revealed no significant block × target type interaction, indicating that the Stroop effect remained stable across blocks and the strategy adopted by the participants might be initiated from the point of the first few trials. Similarly, in the between-block group, a mixed-design ANOVA with target type (within-subjects) and gaze block position (between-subjects) showed no significant interaction, suggesting that the position of the gaze block within the task did not influence the magnitude of the Stroop effect.

Figure 7

Distributional analysis from Experiment 2

A)
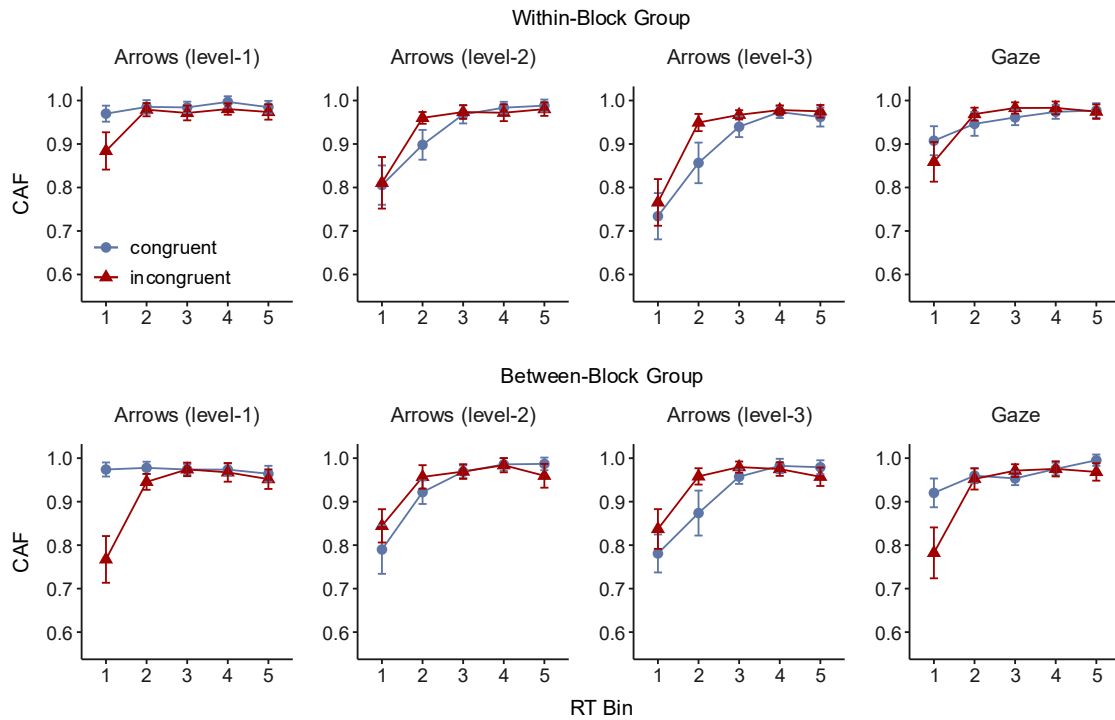
B)
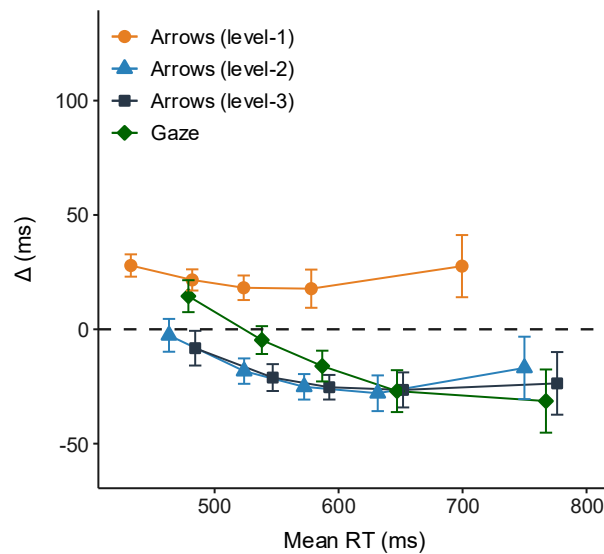
Note. Panel (A) shows CAFs (accuracy across RT bins for congruent and incongruent trials, by target type). Blue-purple points indicate congruent trials, and red triangles indicate incongruent trials. Panel (B) shows delta plots (RT differences between incongruent and congruent trials across mean RT quantiles). As the three-way interaction between group, target type, and quantile was not significant, data in Panel B were collapsed across groups for visualization purposes (see Supplemental Material for the delta plots separated by group). Orange circles represent level-1 arrows, light-blue triangles level-2 arrows, dark-blue squares level-3 arrows, and green diamonds gaze. Error bars represent 95% confidence intervals, adjusted using the Cousineau–Morey method (Morey, 2008).

3.2.4. Discussion

Experiment 2 replicated the patterns observed in Experiment 1 for non-social targets: level-1 arrows elicited an SCE, while level-2 and level-3 arrows produced an RCE. At the distributional level, the RCEs for level-2 and level-3 arrows resembled those previously reported for social stimuli, both in CAF analyses, with higher error rates for congruent than incongruent trials at certain points of the distribution, and in reduced accuracy for both congruency conditions among the fastest responses (Ponce et al., 2025a). Similarly, the delta function analyses revealed a pattern consistent with that previously reported for social stimuli, with the reversal of the congruency effect emerging at mid-to-slower response latencies (Ponce et al., 2025b; Tanaka et al., 2025a).

These findings further support the view that a social component is not required to elicit the RCE (Chen et al., 2022; Tanaka et al., 2024, 2025a). Instead, the critical factor appears to be the difficulty in extracting task-relevant information. Prior work has shown that manipulating target discriminability affects the processing of both relevant (directional) and irrelevant (spatial) information in location-based tasks (Ellinghaus et al., 2024; Mittelstädt & Miller, 2020), supporting the idea that perceptual difficulty can indeed modulate conflict processing. Building on this prior work, our results suggest that when processing of directional information is hindered, the RCE is more likely to emerge.

Nonetheless, not all forms of perceptual interference reliably produce a robust RCE. For example, background segregation manipulations, such as embedding arrows in complex backgrounds, have yielded mixed results. In Román-Caballero et al. (2021a), an RCE was observed when arrows were presented directly on a complex background. However, in their second experiment, the addition of white ovals around the arrows (while keeping the same background) likely made the directional information easier to extract and therefore produced no reversal of the congruency effect. Similarly, no RCE was observed in Román-Caballero et al. (2021b) or Tanaka et al. (2024, Experiment 3), where arrows were embedded in pixeled or mosaic textures. From a distributional perspective, Tanaka et al. (2025a, Supplemental Material) reported no overall RCE with arrows embedded in mosaic backgrounds, although isolated quantiles showed a significant reversal.

Taken together, these findings suggest that background segregation alone may be insufficient to elicit the RCE. Instead, the presence of noisy, overlapping features, such as masking lines used in the present study, appears more effective in triggering the mechanisms underlying the effect. Such manipulations likely engage a combination of task-related processes, including enhanced response capture (Ponce et al., 2025a; 2025b), delayed extraction of directional information (Román-Caballero et al., 2021a, 2021b; Tanaka et al., 2025a), and adjustments to the strength and timing of inhibition (Ponce et al., 2025b; Tanaka et al., 2024, 2025a). These dynamics have been broadly linked to conflict modulation in location-based tasks (Ellinghaus et al., 2024; Luo & Proctor, 2017, 2019; Miller & Schwarz, 2021; Mittelstädt et al., 2023a; Mittelstädt & Miller, 2020; Ridderinkhof, 2002a, 2002b; van Campen et al., 2014, 2018), and their interplay may provide a more specific account of how and when the RCE occurs in the spatial Stroop paradigm (see **General Discussion, Section 4**).

Regarding the group factor, it influenced performance by modulating overall response latencies and accuracy rates, and the Stroop effect was less negative for the between-block manipulation. Thus, several findings aligned with our expectations. For level-1 arrows, the within-block group showed a reduced SCE, evident in both the overall Stroop effect and the earliest parts of the distribution (i.e., first CAF bin and delta quantile). Follow-up comparisons confirmed that this group-related modulation was specific to level-1 arrows,

with no significant differences observed for other non-social targets (see **Supplemental Material**). These findings are consistent with prior work showing reduced interference for easy-to-discriminate stimuli in trialwise (i.e., within-block) designs (Ellinghaus et al., 2024).

For social targets, gaze stimuli elicited an RCE, as expected, and did not significantly differ from other targets in overall Stroop interference. However, a group-level analysis revealed that the RCE was reduced, and not significantly different from zero, in the between-block group (see **Supplemental Material**). Distributional analyses further highlighted differences in conflict dynamics. A significant target type × quantile interaction emerged when gaze stimuli were included—unlike in Experiment 1—suggesting different temporal dynamics of conflict processing for social targets. The main difference observed was the SCE at the first quantile in the delta plot, resembling early effects seen with arrows in complex backgrounds (Tanaka et al., 2025a). Nevertheless, this early SCE was specific to the between-block group, whereas the within-block group showed no such effect (see **Supplemental Material**), replicating prior findings with social stimuli (Ponce et al., 2025b). CAF analyses revealed a complementary dissociation: only the within-block group showed an RCE, although limited to a single bin, replicating patterns previously observed with cropped eyes rather than full-face stimuli (Ponce et al., 2025a). In contrast, the between-block group showed no reversal of the congruent effect.

Interestingly, these group-related differences seem limited to level-1 arrows and gaze targets. One possible explanation is that gaze stimuli used here (cropped faces within a rectangular frame) fall somewhere between level-1 and level-2 arrows in terms of the ease of extracting relevant information, aligning with findings from Ellinghaus et al. (2024) involving easy-to-discriminate stimuli. Supporting this idea, both level-1 arrows and gaze showed lower error rates than the other targets. In both cases, an SCE was observed in terms of accuracy, with gaze marginally reaching a significant result. Furthermore, contrast analyses on the significant three-way interaction between group, target type, and bin (see **Supplemental Material, Figure 2**) revealed the same accuracy hierarchy in the fastest responses: highest for level-1 arrows, followed by gaze, then level-2 and level-3 arrows.

Taken together, these findings suggest that stimuli offering clearer access to task-relevant information (i.e., level-1 arrows and gaze) may be more sensitive to the demands of trial structure, particularly when target type varies unpredictably (Ellinghaus et al., 2024). In line with Hübner and Mishra's (2013) proposal, our results imply that trialwise presentation (within-block) requires greater suppression of irrelevant information to maintain performance, whereas blocked conditions may allow for more selective preparatory control. This interpretation aligns with broader accounts that emphasize the flexibility of inhibitory mechanisms to adapt their onset and strength depending on task demands (De Jong et al., 1994; Mittelstädt et al., 2023a; Ridderinkhof, 2002a, 2002b).

On a broader level, gaze stimuli have shown distinct patterns in previous studies (Ponce et al., 2025b; Tanaka et al., 2025a), suggesting that the temporal dynamics underlying "social RCEs" may be further modulated by a uniquely social mechanism, such as the looking vector. This concept has been proposed to influence interference effects in response to social targets (Hemmerich et al., 2022; Ponce et al., 2025a, 2025b). Supporting this idea, prior research has demonstrated the impact of gaze across multiple stages of cognitive processing (Emery, 2000; Gobbini & Haxby, 2007; Kobayashi & Kohshima, 1997), which include the triggering of automatic attentional orienting (Driver et al., 1999; Ulloa et al., 2018). These mechanisms may introduce additional modulations to conflict effects,

contributing to the patterns observed with social stimuli.

However, fully disentangling the modulatory role of gaze within the RCEs lies beyond the scope of the current study. Future research will be needed to determine which aspects of these effects reflect mechanisms specific to gaze processing or to masking effects. Such investigations could help position social stimuli along a continuum of task-relevant feature accessibility, with full faces potentially representing the most perceptually complex, and thus eliciting the largest RCEs in both CAF and delta function analyses. In this manner, future studies on this nature would clarify the specific contribution of gaze-related dynamics within the spatial Stroop paradigm.

4.   General Discussion

In social attention research, a recurring finding in spatial Stroop tasks is that social stimuli, such as faces or isolated eyes, often reverse the typical congruency pattern: instead of responding faster to congruent trials (as commonly seen with arrows), participants respond more quickly to incongruent ones, producing the RCE (Cañadas & Lupiáñez, 2012; Marotta et al., 2018). This phenomenon has been attributed to unique interference dynamics introduced by social content, which may override the typical spatial processing mechanisms (Edwards et al., 2020; Hemmerich et al., 2022; Marotta et al., 2018).

As outlined in the introduction, several studies highlight robust dissociations between social and non-social targets (Aranda-Martín et al., 2022; Marotta et al., 2019; Narganes-Pineda et al., 2022, 2023; Román-Caballero et al., 2021a, 2021b), supporting the idea that RCE arises from mechanisms specifically engaged by social stimuli. However, more recent research has begun to question this view by examining whether non-social directional targets can also elicit RCEs under specific

perceptual constraints (Chen et al., 2022; Tanaka et al., 2024).

When processing of task-relevant information was hindered, such as by increasing visual complexity (e.g., Román-Caballero et al., 2021a), non-social stimuli occasionally elicited similar congruency effect reversals, although these effects typically have been smaller in magnitude or limited to certain portions of the response distribution (Román-Caballero et al., 2021a; Tanaka et al., 2025a). These findings suggest that the RCE may not be exclusive to social processing, but could instead reflect more general processing constraints related to the accessibility of task-relevant information.

The present study directly tested this hypothesis by manipulating how easily directional information could be extracted from non-social targets. Specifically, arrow stimuli were masked with different levels of visual noise using oblique lines, gradually increasing the difficulty of identifying their direction.

This manipulation reliably and consistently elicited an RCE at the two highest levels of perceptual difficulty, reinforcing the idea that the accessibility of task-relevant features plays a central role in the emergence of the reversal pattern. In doing so, our findings bridge social and non-social accounts by identifying perceptual difficulty as a shared mechanism underlying the RCE.

Beyond highlighting the unique role of perceptual difficulty, our results also align with prior work emphasizing the complex temporal dynamics of this phenomenon. Studies using CAF and delta function analyses suggest that complex stimuli engage multiple processes, including modulations in response capture (Ponce et al., 2025a), changes in the relative speed of task-relevant and -irrelevant information processing, and adjustments to the strength and onset timing of inhibition (Ponce et al., 2025b; Tanaka et al., 2024, 2025a). Together, our

results and these prior findings support the idea that the RCE reflects not a singular mechanism, but an interaction among stimulus complexity, temporal dynamics, and cognitive control.

These dynamics have been widely characterized within the dual-route framework, a theoretical applied account of conflict processing (Hübner & Töbel, 2019; Kelber et al., 2025; Luo & Proctor, 2017; Mittelstädt et al., 2022), and formalized through computational models (Luo & Proctor, 2022; Schwarz & Miller, 2012; Ulrich et al., 2015). According to this framework, interference arises from the interplay between a controlled route, which processes task-relevant information according to instructions, and an automatic route, which reflexively activates responses based on task-irrelevant attributes like spatial location (Cohen et al., 1990; De Jong et al., 1994; Ridderinkhof, 2002a, 2002b; Ulrich et al., 2015).

The automatic route is assumed to exert a fast and transient influence (Ellinghaus et al., 2018, 2024), rising quickly after stimulus onset and then being actively inhibited (Burle et al., 2016; Mittelstadt et al., 2023b; Ridderinkhof, 2002a, 2002b), or passively dissipating after reaching a peak (Hommel, 1993; Ulrich et al., 2015), or both (White et al., 2018).

In our study, masking directional information with overlapping lines may have modulated the onset and strength of automatic activation, enhancing an early spatial influence and increasing the demand on inhibitory control, ultimately shaping response selection. Two mechanisms described in masked priming research may offer useful insights for interpreting this pattern: first, that perceptual input can influence motor-level processes involved in response selection by modulating the strength of motor activation (Eimer & Schlaghecken, 2002; Ocampo & Finkbeiner, 2013; Schlaghecken et al., 2008); and second, that the mask itself can act as an active component that can both engage inhibitory mechanisms (Jaśkowski & Przekoracka-Krawczyk,

2005; Lleras & Enns, 2004; Schmidt et al., 2022) and interact with directional processes, particularly when it contains task-relevant features resembling the masked stimuli (Verleger et al., 2004). This perspective may help explain why our masking manipulation produced stronger RCEs than those observed in studies using mosaic backgrounds, which lack arrow-like structure (Tanaka et al., 2025b).

Although our manipulation did not involve a masked prime in the traditional sense, the simultaneous presentation of mask and target may have elicited a similar dynamic, though based on simultaneous rather than sequential processing, linking early response activation and inhibition. Specifically, our design likely triggered the parallel processing of three types of information: spatial location (as in any location-based task), mask-related features (which, as noted above, can influence response and inhibition), and target-related directional information, which participants were required to process to perform the task.

The first of these, spatial location, has long been recognized as a well-established source of conflict arising from automatic response activation in spatial interference tasks such as Simon and spatial Stroop (Lu & Proctor, 1995; Ridderinkhof, 2002a, 2002b; Viviani et al., 2024). Typically, spatial interference is thought to emerge at the response selection stage (Lu & Proctor, 1995; Rubichi & Pellicano, 2004; Scerrati et al., 2017), reflecting the dimensional overlap between stimulus and response (S-R) features inherent to the stimulus and task design (Kornblum, 1992; Viviani et al., 2024). However, much like findings from masked priming studies, several authors have also proposed a close link between spatial processing and motor mechanisms (Burle et al., 2016; Miller & Roüast, 2016; Scorolli et al., 2015; Treccani et al., 2018), suggesting that spatial location information may compete with directional information not only during response selection but also at the motor

execution level (Mittelstädt et al., 2023b; Servant et al., 2016; Stürmer et al., 2002).

This dynamic is often described in terms of automatic response capture, where task-irrelevant features involuntarily trigger a response based on stimulus location (Burle et al., 2016; Salzer et al., 2019; van Campen et al., 2014, 2018; van Maanen et al., 2018). For example, a rightward stimulus may automatically activate both the selection of a rightward response and the associated right-hand motor activation, even when the correct response is on the left. In our study, such response capture may have been modulated not only by spatial location but also by features embedded in the mask, thereby increasing early response activation and the need for adequate inhibitory control.

CAF analyses have provided a useful behavioral tool for exploring these dynamics. In location-based tasks, incongruent trials typically produce a higher proportion of errors among the fastest responses, with accuracy converging across conditions in later bins (Torres-Quesada et al., 2022; Ulrich et al., 2015). This pattern is thought to reflect the initial influence of irrelevant spatial information, before inhibition takes effect (Salzer et al., 2019; van Campen et al., 2014, 2018; van Maanen et al., 2018) and/or before the spatial code passively decays. This would explain the standard CAF observed with the level-1 arrows.

However, complex stimuli—such as faces, cropped eyes, and the level-2 and level-3 arrows used here—show notable deviations from this typical pattern. In Ponce et al. (2025a), it was emphasized that such stimuli may convey additional information beyond spatial location, processed within the automatic route. While initially, this additional information was attributed to socially specific features (Ponce et al., 2025a), the present findings suggest that a similar effect may arise from more general, mask-related dynamics. In the case of social stimuli, this may reflect shared visual properties, such as overlapping oval contours (e.g.,

pupils, eyes, or facial outlines), which could function as task-relevant mask elements embedded within the visual input, similar to the overlapping oblique lines used here. Although further research is needed to clarify how visual similarity and mask geometry influence interference in the spatial Stroop task, we suspect that these masking effects may have modulated early response capture, leading to reduced accuracy in both congruency conditions, with congruent trials showing even higher error rates than incongruent ones, at specific points in the distribution.

Crucially, this deviation may not reflect enhanced response capture alone but could also indicate additional conflict arising at the level of stimulus identification. The spatial Stroop task is also thought to generate such conflict through S-S overlap (Type-8 ensemble; Kornblum, 1992; Viviani et al., 2024), which may facilitate early processing of mask-related elements. Supporting this view, research on Stroop-like paradigms has shown distinct patterns for S-R and S-S types of conflict (Li et al., 2014; Luo & Proctor, 2017; Scerrati et al., 2017; Torres-Quesada et al., 2022), suggesting that different congruency effects may emerge depending on the source of conflict. Additionally, when the mask contains arrow-like features, it may elicit a form of directionally primed response, similar to those proposed in mask-induced priming accounts (Verleger et al., 2004; Lleras & Enns, 2004), within the automatic route processing stream. This may disrupt the processing of the target's direction and increase congruent-trial errors in the fastest responses, consistent with evidence that automatic activation can briefly spill over into the decision process overseen by the controlled route (Servant et al., 2016; Ülrich et al., 2015).

At a subsequent stage, following the logic of the dual-route framework, automatic activation is held in check by an inhibitory mechanism that receives input from both the automatic and controlled routes (De Jong et al., 1994; Ridderinkhof,

2002a, 2002b; van Campen et al., 2014). This inhibitory mechanism is typically conceptualized as a top-down, feed-forward process (Burle et al., 2004, 2016; Meynier et al., 2009; Ridderinkhof, 2002a, 2002b), and converging evidence describes it as an active process that may complement, rather than rely solely on, the passive dissipation of spatial codes (Burle et al., 2016; Mittelstädt et al., 2023a). Although models vary in how and when the automatic and controlled routes interact, with each other and with inhibition (cf. De Jong et al., 1994; Lu & Proctor, 1995; Kornblum, 1992; Schwarz & Miller, 2012; Ulrich et al., 2015; White et al., 2012), they generally agree that the system must dynamically adapt to context and task demands (Burle et al., 2016; Ellinghaus, et al., 2024; Torres-Quesada et al., 2022; Ulrich et al., 2015).

From this perspective, variations in automatic activation, such as earlier onset or increased strength, should be matched by corresponding adjustments in inhibition. If activation rises sooner or more strongly, as our findings suggest, inhibition must also be initiated earlier and build more rapidly to preserve performance. Indeed, controlled inhibition has been described as a flexible mechanism, adaptable in strength, onset, and buildup rate (Ridderinkhof et al., 2002a, 2002b), and capable of online, reactive adjustment during execution (Burle et al., 2016; Scorolli et al., 2015). These properties offer a plausible account of our results and have previously been associated with RCE patterns observed for social targets (Tanaka et al., 2024, 2025a).

In our study, masked arrows may have amplified early response capture while simultaneously triggering earlier and stronger inhibition, an interpretation supported by the delta plot findings, which showed spatial interference to be markedly reduced among the fastest responses, with the RCE emerging more clearly in the middle range. As noted in the introduction, delta functions represent the time course of congruency effects (De

Jong et al., 1994; Pratte et al., 2010). Thus, this early reduction suggests that spatial interference was initially very low, potentially due to the early increase in inhibition, rather than a background segregation mechanism (Tanaka et al., 2024), contrasting with the typical patterns observed for unmasked arrows (Castel et al., 2007; Ponce et al., 2025b; Tanaka et al., 2025a), arrows embedded in complex backgrounds (Tanaka et al., 2025a), and, more broadly, in location-based tasks involving simpler stimuli (Luo & Proctor, 2019; Mittelstädt & Miller, 2020).

This initial suppression may have created conditions for an interaction between additional automatic information, delayed processing of directional relevant information due to the masking effect, and inhibitory mechanisms, ultimately facilitating the RCE. As proposed in prior work (Ponce et al., 2025b), following the second stage of the dual-stage hypothesis (Tanaka et al., 2024, 2025b), one possible scenario is that on incongruent trials, the incorrect response (based on spatial information) is inhibited very early, as reflected in the delta function, so that when the relevant directional code becomes available, the correct response can proceed quickly and accurately as the only remaining, uninhibited option. In contrast, on congruent trials, the inhibitory mechanism suppresses the correct response initially activated by spatial information. Once the relevant directional code is processed, the system must first release this inhibition before executing the response, resulting in slower RTs and, if not resolved in time, increased early errors, consistent with our CAF findings.

A similar mechanism may underlie gaze-related RCEs. Like masked arrows, gaze can function as a perceptually complex stimulus from which directional information must be extracted amid competing features (Román-Caballero et al., 2021a, 2021b; Tanaka et al., 2024). This complexity may delay access to the relevant signal and recruit inhibition to filter out irrelevant information,

effectively making gaze operate as if it were a masked stimulus. Further supporting this view, reducing the complexity of eye stimuli (e.g., using clearly visible schematic eyes) to facilitate access to relevant information results in the SCE (Chen et al., 2022).

Although faces are generally thought to be processed holistically (Hadders-Algra, 2022; Rossion, 2009; Tanaka & Gordon, 2011), with the eyes serving as an anchor point (Itier et al., 2007; Itier & Preston, 2018; Nemrodov et al., 2014), explicit task instructions to attend to gaze direction may disrupt this holistic processing. If this is the case, the face would be treated part by part, with irrelevant features acting like a mask and engaging inhibitory mechanisms to facilitate extraction of gaze direction. This account is consistent with the RCE observed for inverted faces (Marotta & Lupiáñez, 2018; Tanaka et al., 2023), where holistic processing is impaired and feature-based processing predominates (Rossion, 2009; Tanaka & Farah, 1993; Tanaka & Gordon, 2011). It also might underlie the findings of Narganes-Pineda et al. (2022), who observed the RCE only when participants were explicitly instructed to process gaze direction.

At the same time, we cannot exclude the possibility that gaze engages additional mechanisms tied to its social nature (Hemmerich et al., 2022; Marotta et al., 2019), as suggested by further distinctions observed in distributional analyses (Ponce et al., 2025b; Tanaka et al., 2025a). In addition, prior work has demonstrated that the RCE can be modulated by facial emotion (Jones, 2015; Marotta et al., 2022; Torres-Marín et al., 2017), stimulus familiarity (Ishikawa et al., 2024), and individual social anxiety (Ishikawa et al., 2021). Thus, the RCE for gaze may reflect a combination of general inhibitory dynamics linked to perceptual complexity and uniquely social processes.

Critically, this mechanism does not require additional stages beyond those described in the dual-route framework, and a top-down inhibitory

mechanism. Rather, it suggests that the RCE may result from adaptive modulations of core parameters within the same architecture, shaped by specific stimulus properties and task demands. Nonetheless, this interpretation does not exclude alternative explanations of the RCE, which future research should continue to examine.

For instance, some findings suggest that target onset may automatically engage inhibitory motor-related processes (Treccani et al., 2018), paralleling the dynamics suggested in some masked priming accounts (e.g., *self-inhibition hypothesis;* Schlaghecken et al., 2008). In this view, bottom-up mechanisms contribute an additional layer of control, whereby activating one response automatically inhibits its alternative, and vice versa. This has been used to explain the negative compatibility effect (Eimer & Schlaghecken, 2002; Schlaghecken et al., 2008), and could provide a comparable account for the RCE, where inhibition of one response alternative leads to disinhibition of the opposite response.

Additionally, as discussed earlier, participants appeared to adopt a global strategy based on target predictability (see **Experiment 2**), which modulated the interference effect to some extent. In this context, cognitive control strategies are often conceptualized as either sustained (global) or reactive (trial-by-trial) responses to conflict (Torres-Quesada et al., 2022). However, the RCE persisted for the most complex targets regardless of presentation format, and the direction of Stroop interference remained stable across blocks (see **Supplemental Material**). These patterns suggest that, despite global adjustments, the RCE may be driven by trial-level mechanisms. This view is supported by the dual-route framework and accumulation models, which emphasize single-trial adjustments in conflict resolution via dynamic tuning of key parameters (Lee & Sewell, 2023; Ridderinkhof, 2002a, 2002b; Ulrich et al., 2015).

Overall, these findings suggest that the emergence and magnitude of the RCE are shaped by perceptual complexity, control mechanisms and task-related dynamics. By examining accuracy and interference across the RT distribution, we revealed patterns that would be missed by mean-based analyses. This approach supports prior recommendations to use distributional methods to capture the temporal profile of conflict (Balota & Yap, 2011; Ellinghaus et al., 2024; Mittelstädt & Miller, 2020; Pratte et al., 2010). Moreover, our results align with those of Román-Caballero et al. (2021a, 2021b), who found that reductions in the SCE often co-occur with increases in the RCE, suggesting a functional link between them. Although a full examination of this relationship was not the focus of the present study, our findings underscore the need for future research to clarify when the RCE is enhanced or suppressed.

5. Conclusions

This study reveals that the RCE, typically observed with social targets, can also be elicited with non-social stimuli when directional information is masked by overlapping features. This supports the view that the RCE is not exclusive to social processing but can arise from general constraints on information accessibility and cognitive control. By integrating insights from the dual-route framework and masked priming literature, we suggest that early response activation, inhibitory mechanisms, and visual complexity interact to shape spatial interference patterns. Distributional analyses revealed that the RCE unfolds over time, with minimal interference in early responses and stronger reversal at mid-range latencies. Importantly, the comparison between masked arrows and gaze highlights a potential bridge between social and non-social accounts: whereas arrows require an explicit masking manipulation, gaze may spontaneously engage inhibitory mechanisms due to its perceptually complex configuration. Taken together, these results suggest that the RCE reflects adaptive control processes that flexibly adjust to perceptual complexity and task context. Further research is needed to clarify how these factors interact to enhance or suppress this effect.

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Declaration of Interest Statement

None of the authors have any financial interest or conflict of interest.

Preregistration and Data Availability

All hypotheses, experimental design, and analysis plans were preregistered. The preregistrations, together with the data, experimental materials, and analysis scripts that support the findings of this study, are publicly available at the Open Science Framework (OSF) and can be accessed at https://osf.io/yvcak/.

References

Apperly, I. A., & Butterfill, S. A. (2009). Do humans have two systems to track beliefs and belief-like states? *Psychological Review, 116*(4),

953–970.
https://doi.org/10.1037/a0016923

Aranda-Martín, B., Ballesteros-Duperón, M. Á., & Lupiáñez, J. (2022). What gaze adds to arrows: Changes in attentional response to gaze versus arrows in childhood and adolescence. *British Journal of Psychology, 113*, 718-738.
https://doi.org/10.1111/bjop.12552

Aranda-Martín, B., Lupiáñez, J., & Ballesteros-Duperón, M. A. (2023). Attentional differences between gaze and arrows processing: where vs. What are looking at. *Psicológica, 44*(2), e15274.
https://doi.org/10.20350/digitalCSIC/15274

Balota, D. A., & Yap, M. J. (2011). Moving beyond the mean in studies of mental chronometry: The power of response time distributional analyses. *Current Directions in Psychological Science, 20*(3), 160–166.
https://doi.org/10.1177/0963721411408885

Banich M. T. (2019). The Stroop Effect Occurs at Multiple Points Along a Cascade of Control: Evidence From Cognitive Neuroscience Approaches. *Frontiers in Psychology, 10*, 2164.
https://doi.org/10.3389/fpsyg.2019.02164

Baron-Cohen, S. (1994). How to build a baby that can read minds: Cognitive mechanisms in mindreading. *Cahiers de Psychologie Cognitive/Current Psychology of Cognition, 13*(5), 513–552.

Bonventre, S., & Marotta, A. (2023). Is the reversed congruency effect unique to the eye-gaze? Investigating the effects of finger pointing, eye-gaze, and arrow stimuli on spatial interference. *Frontiers in Cognition, 2*.
https://doi.org/10.3389/fcogn.2023.1135435

Braver T. S. (2012). The variable nature of cognitive control: a dual mechanisms framework. *Trends in Cognitive Sciences, 16*(2), 106–113.
https://doi.org/10.1016/j.tics.2011.12.010

Brignani, D., Guzzon, D., Marzi, C.A., & Miniussi, C. (2009). Attentional orienting induced by arrows and eye-gaze compared with an endogenous cue. *Neuropsychologia, 47*, 370–381.
https://doi.org/10.1016/j.neuropsychologia.2008.09.011

Burle, B., van den Wildenberg, W. P. M., Spieser, L., & Ridderinkhof, K. R. (2016). Preventing (impulsive) errors: Electrophysiological evidence for online inhibitory control over incorrect responses. *Psychophysiology, 53*(7), 1008–1019. https://doi.org/10.1111/psyp.12647

Cañadas, E., & Lupiáñez, J. (2012). Spatial interference between gaze direction and gaze location: A study on the eye contact effect. *Quarterly Journal of Experimental Psychology, 65*(8), 1586–1598.
https://doi.org/10.1080/17470218.2012.659190

Castel, A. D., Balota, D. A., Hutchison, K. A., Logan, J. M., & Yap, M. J. (2007). Spatial attention and response control in healthy younger and older adults and individuals with Alzheimer's disease: evidence for disproportionate selection impairments in the Simon task. *Neuropsychology*, *21*(2), 170–182. https://doi.org/10.1037/0894-4105.21.2.170

Chacon-Candia, J. A., Roman-Caballero, R., Aranda-Martin, B., Casagrande, M., Lupianez, J., & Marotta, A. (2023). Are there quantitative differences between eye-gaze and arrow cues? A meta-analytic answer to the debate and a call for qualitative differences.

Neuroscience & Biobehavioral Reviews, 144, 104993. https://doi.org/10.1016/j.neubiorev.2022.104993

Chacón-Candia, J. A., Ponce, R., & Marotta, A. (2024). The reverse congruency effect elicited by eye-gaze as a function of attention-deficit/hyperactivity disorder symptoms. *Frontiers in Psychology, 15*, 1377379. https://doi.org/10.3389/fpsyg.2024.1377379

Champely, S., Ekstrom, C., Dalgaard, P., Gill, J., Weibelzahl, S., Anandkumar, A., Ford, C., Volcic, R., & De Rosario, H. (2020). pwr: Basic functions for power analysis. Software https://cran.r-project.org/web/packages/pwr/

Chen, Z., Thomas, R. H., & Chen, M. S. (2022). Do gaze and non-gaze stimuli trigger different spatial interference effects? It depends on stimulus perceivability. *Frontiers in Psychology, 13*, 5373. https://doi.org/10.3389/fpsyg.2022.801151

Cohen, J. D., Dunbar, K., & McClelland, J. L. (1990). On the control of automatic processes: A parallel distributed processing account of the Stroop effect. *Psychological Review, 97*(3), 332–361. https://doi.org/10.1037/0033-295x.97.3.332

Cole, G.G., & Millett, A.C. (2019). The closing of the theory of mind: A critique of perspective-taking. *Psychonomic Bulletin & Review, 26*, 1787–1802. https://doi.org/10.3758/s13423-019-01657-y

Dalmaso, M., Galfano, G., & Castelli, L. (2023). Are eyes special? Gaze, but not pointing gestures, elicits a reversed congruency effect in a spatial Stroop task. *Attention, Perception & Psychophysics*, *85*(8), 2547–2552. https://doi.org/10.3758/s13414-023-02774-6

De Jong, R., Liang, C. C., & Lauber, E. (1994). Conditional and unconditional automaticity: A dual-process model of effects of spatial stimulus-response correspondence. Journal of Experimental Psychology: *Human Perception & Performance, 20*, 731–750. https://doi.org/10.1037/0096-1523.20.4.731

Driver, J., Davis, G., Ricciardelli, P., Kidd, P., Maxwell, E., & Baron-Cohen, S. (1999). Gaze perception triggers reflexive visuospatial orienting. *Visual Cognition, 6*(5), 509–540. https://doi.org/10.1080/135062899394920

Edwards, S. G., Seibert, N., & Bayliss, A. P. (2020). Joint attention facilitates observed gaze direction discrimination. *Quarterly Journal of Experimental Psychology, 73*(1), 80–90. https://doi.org/10.1177/1747021819867901

Eimer, M., & Schlaghecken, F. (2002). Links between conscious awareness and response inhibition: Evidence from masked priming. *Psychonomic Bulletin & Review, 9*(3), 514–520. https://doi.org/10.3758/BF03196307

Ellinghaus, R., Liepelt, R., Mackenzie, I. G., & Mittelstädt, V. (2024). Perceptual target discriminability modulates the Simon effect beyond the fading of distractor-based activation: Insights from delta plots and diffusion model analyses. Journal of experimental psychology. *Human Perception and Performance, 50*(8), 842–858. https://doi.org/10.1037/xhp0001211

Ellinghaus, R., Karlbauer, M., Bausenhart, K. M., & Ulrich, R. (2018). On the time-course of

automatic response activation in the Simon task. *Psychological Research*, *82*(4), 734–743. https://doi.org/10.1007/s00426-017-0860-z

Emery N. J. (2000). The eyes have it: the neuroethology, function and evolution of social gaze. *Neuroscience and Biobehavioral Reviews, 24*(6), 581–604. https://doi.org/10.1016/s0149-7634(00)00025-7

Gobbini, M. I., & Haxby, J. V. (2007). Neural systems for recognition of familiar faces. *Neuropsychologia, 45*(1), 32–41. https://doi.org/10.1016/j.neuropsychologia.2006.04.015

Grange, J. A. (2016). flankr: An R package implementing computational models of attentional selectivity. *Behavior Research Methods, 48*(2), 528–541. https://doi.org/10.3758/s13428-015-0615-y

Hadders-Algra M. (2022). Human face and gaze perception is highly context specific and involves bottom-up and top-down neural processing. *Neuroscience and Biobehavioral Reviews*, *132*, 304–323. https://doi.org/10.1016/j.neubiorev.2021.11.042

Hemmerich, K., Narganes-Pineda, C., Marotta, A., Martín-Arévalo, E., Jiménez, L., & Lupiáñez, J. (2022). Gaze elicits social and nonsocial attentional orienting: An interplay of shared and unique conflict processing mechanisms. *Journal of Experimental Psychology*: *Human Perception and Performance, 48*(8), 824–841. https://doi.org/10.1037/xhp0001015

Heitz R. P. (2014). The speed-accuracy tradeoff: history, physiology, methodology, and behavior. *Frontiers in Neuroscience, 8*, 150. https://doi.org/10.3389/fnins.2014.00150

Hübner, R., & Mishra, S. (2013). Evidence for strategic suppression of irrelevant activation in the Simon task. *Acta Psychologica, 144*(1), 166–172. https://doi.org/10.1016/j.actpsy.2013.05.012

Hübner, R., & Töbel, L. (2019). Conflict resolution in the Eriksen flanker task: Similarities and differences to the Simon task. *PloS One, 14*(3), e0214203. https://doi.org/10.1371/journal.pone.0214203

Hyndman, R.J. and Fan, Y. (1996) Sample Quantiles in Statistical Packages. *American Statistician*, *50*, 361–365. http://dx.doi.org/10.2307/2684934

Ishikawa, K., Oyama, T., & Okubo, M. (2021). The malfunction of domain-specific attentional process in social anxiety: attentional process of social and non-social stimuli. *Cognition & Emotion, 35*(6), 1163–1174. https://doi.org/10.1080/02699931.2021.1935217

Ishikawa, K., Oyama, T., Tanaka, Y., & Okubo, M. (2024). Perceiving social gaze produces the reversed congruency effect. *Quarterly Journal of Experimental Psychology* (2006), 17470218241232981. Advance online publication. https://doi.org/10.1177/17470218241232981

Itier, R. J., Alain, C., Sedore, K., & McIntosh, A. R. (2007). Early face processing specificity: it's in the eyes!. *Journal of Cognitive Neuroscience*, *19*(11), 1815–1826. https://doi.org/10.1162/jocn.2007.19.11.1815

Itier, R. J., & Preston, F. (2018). Increased Early Sensitivity to Eyes in Mouthless Faces: In Support of the LIFTED Model of Early Face

Processing. *Brain Topography*, *31*(6), 972–
984. https://doi.org/10.1007/s10548-018-
0663-6

Jaśkowski, P., & Przekoracka-Krawczyk, A. (2005). On
the role of mask structure in subliminal
priming. *Acta Neurobiologiae
Experimentalis*, *65*(4), 409–417.
https://doi.org/10.55782/ane-2005-1569

Jones, S. (2015). The mediating effects of facial
expression on spatial interference between
gaze direction and gaze location. *The
Journal of General Psychology, 142*(2), 106–
117.
https://doi.org/10.1080/00221309.2015.10
09822

Kelber, P., Gierlich, M., Göth, J., Jeschke, M. G.,
Mackenzie, I. G., & Mittelstädt, V. (2023). A
diffusion model analysis of object-based
selective attention in the Eriksen flanker
task. *Experimental Psychology, 70*(3), 155–
170. https://doi.org/10.1027/1618-
3169/a000588

Kobayashi, H., & Kohshima, S. (1997). Unique
morphology of the human
eye. *Nature*, *387*(6635), 767–768.
https://doi.org/10.1038/42842

Kornblum, S. (1992). Dimensional overlap and
dimensional relevance in stimulus–response
and stimulus–stimulus compatibility. In G. E.
Stelmach & J. Requin (Eds.), *Tutorials in
Motor Behavior*, (vol. 2, pp. 743–777).
Dordrecht: Kluwer Academic Publishers,
1991.

Lakens, D., & Caldwell, A. R. (2021). Simulation-
based power analysis for factorial analysis
of variance designs. *Advances in Methods
and Practices in Psychological Science, 4*(1),
Article 2515245920951503.
https://doi.org/10.1177/251524592095150
3

Lange K, Kühn S, Filevich E (2015) Correction: "Just
Another Tool for Online Studies" (JATOS):
An Easy Solution for Setup and
Management of Web Servers Supporting
Online Studies. *PloS One 10*(7): e0134073.
https://doi.org/10.1371/journal.pone.0134
073

Lee, P. S., & Sewell, D. K. (2024). A revised diffusion
model for conflict tasks. *Psychonomic
Bulletin & Review*, *31*(1), 1–31.
https://doi.org/10.3758/s13423-023-
02288-0

Li, Q., Nan, W., Wang, K., & Liu, X. (2014).
Independent processing of stimulus-
stimulus and stimulus-response
conflicts. *PloS One*, *9*(2), e89249.
https://doi.org/10.1371/journal.pone.0089
249

Lleras, A., & Enns, J. T. (2004). Negative
compatibility or object updating? A
cautionary tale of mask-dependent
priming. *Journal of Experimental
Psychology. General*, *133*(4), 475–493.
https://doi.org/10.1037/0096-
3445.133.4.475

Lu, C.-H., & Proctor, R. W. (1995). The influence of
irrelevant location information on
performance: A review of the Simon and
spatial Stroop effects. *Psychonomic Bulletin
& Review, 2*(2), 174–207.
https://doi.org/10.3758/BF03210959

Luo, C., & Proctor, R. W. (2017). How different
location modes influence responses in a
Simon-like task. *Psychological Research,
81*(6), 1125–1134.
https://doi.org/10.1007/s00426-016-0809-
7

Luo, C., & Proctor, R. W. (2019). How different direct
association routes influence the indirect
route in the same Simon-like task.

Psychological Research, 83(8), 1733–1748. https://doi.org/10.1007/s00426-018-1024-5

Luo, C., & Proctor, R. W. (2022). A diffusion model for the congruency sequence effect. *Psychonomic Bulletin & Review*, *29*(6), 2034–2051. https://doi.org/10.3758/s13423-022-02119-8

Marotta, A., Aranda-Martín, B., De Cono, M., Ballesteros-Duperón, M. Á., Casagrande, M., & Lupiáñez, J. (2022). Integration of Facial Expression and Gaze Direction in Individuals with a High Level of Autistic Traits. *International Journal of Environmental Research and Public Health*, *19*(5), 2798. https://doi.org/10.3390/ijerph19052798

Marotta, A., & Lupiáñez, J. (2018). *Reversing spatial Stroop effect with upright and inverted faces* [Unpublished manuscript]. Open Science Framework. https://doi.org/10.17605/OSF.IO/9YB6A

Marotta, A., Lupiáñez, J., Román-Caballero, R., Narganes-Pineda, C., & Martín-Arévalo, E. (2019). Are eyes special? Electrophysiological and behavioural evidence for a dissociation between eye-gaze and arrows attentional mechanisms. *Neuropsychologia, 129*, 146–152. https://doi.org/10.1016/j.neuropsychologia.2019.03.017

Marotta, A., Román-Caballero, R., & Lupiáñez, J. (2018). Arrows don't look at you: Qualitatively different attentional mechanisms triggered by gaze and arrows. *Psychonomic Bulletin & Review*, *25*(6), 2254–2259. https://doi.org/10.3758/s13423-018-1457-2

Mathôt, S., Schreij, D., & Theeuwes, J. (2012). OpenSesame: an open-source, graphical experiment builder for the social sciences. *Behavior Research Methods*, *44*(2), 314–324. https://doi.org/10.3758/s13428-011-0168-7

Meynier, C., Burle, B., Possamaï, C.-A., Vidal, F., & Hasbroucq, T. (2009). Neural inhibition and interhemispheric connections in two-choice reaction time: A Laplacian ERP study. *Psychophysiology, 46*(4), 726–730. https://doi.org/10.1111/j.1469-8986.2009.00818.x

Miller, J., & Roüast, N. M. (2016). Dissociations of spatial congruence effects across response measures: an examination of delta plots. *Psychological Research*, *80*(5), 805–820. https://doi.org/10.1007/s00426-015-0694-5

Miller, J., & Schwarz, W. (2021). Delta plots for conflict tasks: An activation-suppression race model. *Psychonomic Bulletin & Review, 28*(6), 1776–1795. https://doi.org/10.3758/s13423-021-01900-5

Mittelstädt, V., Mackenzie, I. G., Koob, V., & Janczyk, M. (2023a). The impact of distractor relevance on the strength and timing of cognitive control: Evidence from delta plots and diffusion model analyses. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 49*(10), 1588–1614. https://doi.org/10.1037/xlm0001281

Mittelstädt, V., Leuthold, H., & Mackenzie, I. G. (2023b). Motor demands influence conflict processing in a mouse-tracking Simon task. *Psychological Research*, *87*(6), 1768–1783. https://doi.org/10.1007/s00426-022-01755-y

Mittelstädt, V., & Miller, J. (2020). Beyond mean reaction times: Combining distributional analyses with processing stage manipulations in the Simon task. *Cognitive Psychology*, *119*, Article 101275. https://doi.org/10.1016/j.cogpsych.2020.101275

Mittelstädt, V., Miller, J., Leuthold, H., Mackenzie, I. G., & Ulrich, R. (2022). The time-course of distractor-based activation modulates effects of speed-accuracy tradeoffs in conflict tasks. *Psychonomic Bulletin & Review, 29*(3), 837–854. https://doi.org/10.3758/s13423-021-02003-x

Morey, R. D. (2008). Confidence intervals from normalized data: A correction to Cousineau (2005). *Tutorials in Quantitative Methods for Psychology, 4*(2), 61–64. https://doi.org/10.20982/tqmp.04.2.p061

Mundy P. (2018). A review of joint attention and social-cognitive brain systems in typical development and autism spectrum disorder. *The European Journal of Neuroscience, 47*(6), 497–514. https://doi.org/10.1111/ejn.13720

Narganes-Pineda, C., Chica, A. B., Lupiáñez, J., & Marotta, A. (2022). Explicit vs. Implicit spatial processing in arrow vs. Eye-gaze spatial congruency effects. *Psychological Research, 87*(1), 242–259. https://doi.org/10.1007/s00426-022-01659-x

Narganes-Pineda, C., Paz-Alonso, P. M., Marotta, A., Lupiáñez, J., & Chica, A. B. (2023). Neural basis of social attention: common and distinct mechanisms for social and nonsocial orienting stimuli. *Cerebral Cortex*, *33*(22), 11010–11024. https://doi.org/10.1093/cercor/bhad339

Nemrodov, D., Anderson, T., Preston, F. F., & Itier, R. J. (2014). Early sensitivity for eyes within faces: a new neuronal account of holistic and featural processing. *NeuroImage*, *97*, 81–94. https://doi.org/10.1016/j.neuroimage.2014.04.042

Ocampo, B., & Finkbeiner, M. (2013). The negative compatibility effect with relevant masks: a case for automatic motor inhibition. *Frontiers in Psychology*, *4*, 822. https://doi.org/10.3389/fpsyg.2013.00822

Parris, B. A., Hasshim, N., Wadsley, M., Augustinova, M., & Ferrand, L. (2022). The loci of Stroop effects: a critical review of methods and evidence for levels of processing contributing to color-word Stroop effects and the implications for the loci of attentional selection. *Psychological Research, 86*(4), 1029–1053. https://doi.org/10.1007/s00426-021-01554-x

Ponce, R., Lupiáñez, J., González-García, C., Casagrande, M., & Marotta, A. (2025a). Exploring the spatial interference effects elicited by social and non-social targets: A conditional accuracy function approach. *British Journal of Psychology, 116*(1), 69–88. https://doi.org/10.1111/bjop.12735

Ponce, R., Lupiáñez, J., González-García, C., Casagrande, M., & Marotta, A. (2025b). Investigating the gaze-driven reversed congruency effect in the spatial Stroop task: A distributional approach. *British Journal of Psychology*, *116*(4), 1107–1127. https://doi.org/10.1111/bjop.70004

Pratte, M. S., Rouder, J. N., Morey, R. D., & Feng, C. (2010). Exploring the differences in distributional properties between Stroop and Simon effects using delta plots. *Attention, Perception & Psychophysics,*

72(7), 2013–2025. https://doi.org/10.3758/APP.72.7.2013

Ratcliff, R. (1979). Group reaction time distributions and an analysis of distribution statistics. *Psychological Bulletin, 86*(3), 446–461. https://doi.org/10.1037/0033-2909.86.3.446

Ridderinkhof, R. K. (2002a). Activation and suppression in conflict tasks: Empirical clarification through distributional analyses. In W. Prinz & B. Hommel (Ed.), *Common mechanisms in perception and action: Attention and performance XIX* (pp. 494–519). Oxford University Press.

Ridderinkhof, K. R. (2002b). Micro-and macro-adjustments of task set: Activation and suppression in conflict tasks. *Psychological Research, 66*(4), 312–323. https://doi.org/10.1007/s00426-002-0104-7

Román-Caballero, R., Marotta, A., and Lupiáñez, J. (2021a). Target–background segregation in a spatial interference paradigm reveals shared and specific attentional mechanisms triggered by gaze and arrows. *Journal of Experimental Psychology: Human Perception and Performance, 47*, 1561–1573. https://doi.org/10.1037/xhp0000953

Román-Caballero, R., Marotta, A., & Lupiáñez, J. (2021). Spatial interference triggered by gaze and arrows. The role of target background on spatial interference. *Psicológica, 42*(2), 192–209. https://doi.org/10.2478/psicolj-2021-0010

Rossion, B. (2009). Distinguishing the cause and consequence of face inversion: The perceptual field hypothesis. *Acta Psychologica, 132*(3), 300–312. https://doi.org/10.1016/j.actpsy.2009.08.002

Rubichi, S., & Pellicano, A. (2004). Does the Simon effect affect movement execution? *European Journal of Cognitive Psychology, 16*(6), 825–840. https://doi.org/10.1080/09541440340000367

Salzer, Y., de Hollander, G., van Maanen, L., & Forstmann, B. U. (2019). A neural substrate of early response capture during conflict tasks in sensory areas. *Neuropsychologia, 124*, 226–235. https://doi.org/10.1016/j.neuropsychologia.2018.12.009

Scerrati, E., Lugli, L., Nicoletti, R., & Umiltà, C. (2017). Comparing Stroop-like and Simon Effects on Perceptual Features. *Scientific reports, 7*(1), 17815. https://doi.org/10.1038/s41598-017-18185-1

Schlaghecken, F., Rowley, L., Sembi, S., Simmons, R., & Whitcomb, D. (2008). The negative compatibility effect: A case for self-inhibition. *Advances in Cognitive Psychology, 3*(1-2), 227–240. https://doi.org/10.2478/v10053-008-0027-y

Schmidt, T., Panis, S., Wolkersdorfer, M. P., & Vorberg, D. (2022). Response inhibition in the negative compatibility effect in the absence of inhibitory stimulus features. *Open Psychology, 4*(1), 219–230. https://doi.org/10.1515/psych-2022-0012

Schwarz, W., & Miller, J. (2012). Response time models of delta plots with negative-going slopes. *Psychonomic Bulletin & Review, 19*(4), 555–574. https://doi.org/10.3758/s13423-012-0254-6

Scorolli, C., Pellicano, A., Nicoletti, R., Rubichi, S., & Castiello, U. (2015). The Simon effect in action: planning and/or on-line control effects?. *Cognitive Science*, *39*(5), 972–991. https://doi.org/10.1111/cogs.12188

Servant, M., White, C., Montagnini, A., & Burle, B. (2016). Linking Theoretical Decision-making Mechanisms in the Simon Task with Electrophysiological Data: A Model-based Neuroscience Study in Humans. *Journal of Cognitive Neuroscience*, *28*(10), 1501–1521. https://doi.org/10.1162/jocn_a_00989

Speckman, P. L., Rouder, J. N., Morey, R. D., & Pratte, M. S. (2008). Delta Plots and Coherent Distribution Ordering. *The American Statistician, 62*(3), 262–266. https://doi.org/10.1198/000313008X333493

Spinelli, G., Morton, J. B., & Lupker, S. J. (2022). Both task-irrelevant and task-relevant information trigger reactive conflict adaptation in the item-specific proportion-congruent paradigm. *Psychonomic Bulletin & Review, 29*(6), 2133–2145. https://doi.org/10.3758/s13423-022-02138-5

Stürmer, B., Leuthold, H., Soetens, E., Schröter, H., & Sommer, W. (2002). Control over location-based response activation in the Simon task: behavioral and electrophysiological evidence. *Journal of Experimental Psychology. Human Perception and Performance*, *28*(6), 1345–1363. https://doi.org/10.1037//0096-1523.28.6.1345

Tanaka, J. W., & Farah, M. J. (1993). Parts and wholes in face recognition. *The Quarterly journal of experimental psychology. A, Human Experimental Psychology*, *46*(2), 225–245.

https://doi.org/10.1080/14640749308401045

Tanaka, J. W., & Gordon, I. (2011). Features, configuration and holistic face processing. In A. Calder, G. Rhodes, M. Johnson, & J. Haxby (Eds.), *The Oxford handbook of face perception* (pp. 177–194). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199559053.013.0010

Tanaka, Y., Ishikawa, K., Oyama, T., & Okubo, M. (2023). Face inversion does not affect the reversed congruency effect of gaze. *Psychonomic Bulletin & Review, 30*(3), 974–982. https://doi.org/10.3758/s13423-022-02208-8

Tanaka, Y., Ishikawa, K., Oyama, T., & Okubo, M. (2024). Eye gaze is not unique: The reversed congruency effect on gaze and tongue targets. *Quarterly Journal of Experimental Psychology, 77*(7), 1485–1497. https://doi.org/10.1177/17470218231203187

Tanaka, Y., Oyama, T., Ishikawa, K., & Okubo, M. (2025a). Temporal dynamics of activation and suppression in a spatial Stroop task: A distribution analysis on gaze and arrow targets. *Attention, Perception & Psychophysics, 87*(2), 367–383. https://doi.org/10.3758/s13414-024-02993-5

Tanaka, Y., Oyama, T., Ishikawa, K., & Okubo, M. (2025b). Trial-by-trial modulations in a spatial Stroop task: A distribution analysis on social and non-social targets. *Quarterly Journal of Experimental Psychology, 0*(0). https://doi.org/10.1177/17470218251332591

Torres-Marín, J., Carretero-Dios, H., Acosta, A., & Lupiáñez, J. (2017). Eye contact and fear of

being laughed at in a gaze discrimination task. *Frontiers in Psychology, 8*, 1–14. https://doi.org/10.3389/fpsyg.2017.01954

Torres-Quesada, M., Leiva, A., Lupiáñez, J., Humphreys, G., & Funes, M. J. (2022). A process-specific approach in the study of normal aging deficits in cognitive control: What deteriorates with age?. *Acta Psychologica*, *227*, 103625. https://doi.org/10.1016/j.actpsy.2022.1036 25

Treccani, B., Cona, G., Milanese, N., & Umiltà, C. (2018). Sequential modulation of (bottom–up) response activation and inhibition in a response conflict task: A single-pulse transcranial magnetic stimulation study. *Psychological Research, 82*(4), 771–786. https://doi.org/10.1007/s00426-017-0863-9

Ulloa, J. L., Dubal, S., Yahia-Cherif, L., & George, N. (2018). Gaze perception induces early attention orienting effects in occipito-parietal regions. *Neuropsychologia*, *109*, 173–180. https://doi.org/10.1016/j.neuropsychologia .2017.12.029

Ulrich, R., Schröter, H., Leuthold, H., & Birngruber, T. (2015). Automatic and controlled stimulus processing in conflict tasks: Superimposed diffusion processes and delta functions. *Cognitive Psychology, 78*, 148–174. https://doi.org/10.1016/j.cogpsych.2015.02 .005

van Campen, A. D., Kunert, R., van den Wildenberg, W. P. M., & Ridderinkhof, K. R. (2018). Repetitive transcranial magnetic stimulation over inferior frontal cortex impairs the suppression (but not expression) of action impulses during action conflict. *Psychophysiology, 55*(3), e13003. https://doi.org/10.1111/psyp.13003

van Campen, A. D., Keuken, M. C., van den Wildenberg, W. P., & Ridderinkhof, K. R. (2014). TMS over M1 reveals expression and selective suppression of conflicting action impulses. *Journal of Cognitive Neuroscience, 26*(1), 1–15. https://doi.org/10.1162/jocn_a_00482

van Maanen, L., Katsimpokis, D., & van Campen, A. D. (2019). Fast and slow errors: Logistic regression to identify patterns in accuracy-response time relationships. *Behavior Research Methods*, *51*(5), 2378–2389. https://doi.org/10.3758/s13428-018-1110-z

Verleger, R., Jaśkowski, P., Aydemir, A., van der Lubbe, R. H. J., & Groen, M. (2004). Qualitative differences between conscious and nonconscious processing? On inverse priming induced by masked arrows. *Journal of Experimental Psychology. General*, *133*(4), 494–515. https://doi.org/10.1037/0096-3445.133.4.494

Viviani, G., Visalli, A., Montefinese, M., Vallesi, A., & Ambrosini, E. (2024). The Stroop legacy: A cautionary tale on methodological issues and a proposed spatial solution. *Behavior Research Methods, 56*(5), 4758–4785. https://doi.org/10.3758/s13428-023-02215-0

White, C. N., Brown, S., & Ratcliff, R. (2012). A test of Bayesian observer models of processing in the Eriksen flanker task. *Journal of Experimental Psychology: Human Perception and Performance, 38*(2), 489–497. https://doi.org/10.1037/a0026065

White, C. N., Servant, M., & Logan, G. D. (2018). Testing the validity of conflict drift-diffusion models for use in estimating cognitive processes: A parameter-recovery study. *Psychonomic Bulletin & Review*, *25*(1), 286–301.

https://doi.org/10.3758/s13423-017-1271-2

Yang, D. Y., Rosenblau, G., Keifer, C., & Pelphrey, K. A. (2015). An integrative neural model of social perception, action observation, and theory of mind. *Neuroscience and Biobehavioral Reviews, 51*, 263–275. https://doi.org/10.1016/j.neubiorev.2015.01.020