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Trial-by-trial modulations in the orienting of attention elicited by gaze and arrow cues

Francesca Ciardo[1,#a], Paola Ricciardelli [2, 3], Cristina Iani [1, 4]

[(1)] Department of Communication and Economics, University of Modena and Reggio Emilia, Viale Allegri, 9, 42121 Reggio Emilia, Italy

[(2)] Department of Psychology, University of Milano-Bicocca, Edificio U6, Piazza dell'Ateneo Nuovo 1, 20126 Milan, Italy

[(3)] Milan Centre for Neuroscience, Piazza dell'Ateneo Nuovo 1, 20126, Milan, Italy

[(4)] Interdepartmental Center of Neuroscience and Neurotechnology, University of Modena and Reggio Emilia, Via Campi 287, 41125, Modena, Italy

[#a] Current address: S4HRI Group, Social Cognition in Human-Robot Interaction, Istituto Italiano di Tecnologia, Via Enrico Melen 83, 16145, Genova, Italy

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Address for Correspondence:

Cristina Iani
Dipartimento di Comunicazione ed Economia
Viale Allegri 9
42121 Reggio Emilia, ITALY
E-mail: cristina.iani@unimore.it

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ABSTRACT [199 words]

Recent findings suggested that the orienting of attention towards gazed at locations (i.e., the gaze cueing effect) could result from the conflict emerging in incongruent trials between the spatial information conveyed by gaze direction and the target spatial position. In two experiments, we assessed this hypothesis by investigating whether this effect is influenced by the same trial-by-trial modulations that are reported in a spatial conflict task, i.e. the Simon task. In Experiment 1 we compared the trial-by-trial modulations emerging in the Simon task with those emerging in a gaze cueing task, while in Experiment 2 we compared gaze and arrows cues. Trial-by-trial modulations were evident in both tasks. In the Simon task, correspondence sequence affected both corresponding and noncorresponding responses, this resulting in a larger Simon effect when the preceding trial was corresponding and an absent effect when the preceding trial was noncorresponding. Differently, in the gaze cueing task congruence sequence affected only congruent responses with faster responses when the preceding trial was congruent compared to when it was incongruent, resulting in a larger gaze cuing effect when the preceding trial was congruent. Same results were evident with nonpredictive arrow cues. These findings speak against a spatial conflict account.

Key words: Trial-by-trial modulations; gaze and arrows cueing effects; spatial conflict; Simon effect; orienting of attention.

Introduction

Several studies have shown that observers respond faster to targets in locations that were cued by others' gaze direction than to uncued targets, even when gaze cues are nonpredictive (Friesen & Kingston, 1998; Driver et al., 1999; Langton, Watt, & Bruce, 2000). When schematic faces are used, this effect - i.e., the gaze cueing effect - has been shown to develop at short cue-target intervals (i.e. ≤100 ms) and to diminish at longer intervals (i.e. ≥ 600 ms); similarly to the congruency effect elicited by over-learned symbols such as arrows (e.g. Frischen & Kingstone, 1998; Galfano et al., 2012; Gayzur et al., 2014; Hommel, Pratt, Colzato, & Godijn, 2001; Tipples, 2002). A similar pattern of results has been reported when pictures of real faces were used as distractors with significantly faster reaction times (RTs) for cued than un-cued targets at 300- and 700-ms cue-target intervals, even though the direction of gaze was entirely nonpredictive of target location or identity (e.g., Diver et al., 1999; Hietanen & Leppänen, 2003). Taken together, the mentioned evidence suggests that gaze and arrow cues may trigger a rapid reflexive orienting of attention.

As regards the orienting of attention driven by gaze cues, the results of recent studies seem to suggest that it is likely to be a product of both exogenous (stimulus-driven) and endogenous (goal-driven) orienting mechanisms. Indeed, they showed that it can be influenced by top-down processes that interpret the averted gaze based on its relevance for the task (e.g., Ricciardelli, Carcagno, Vallar, & Bricolo, 2013) and in comparison to others stimuli in the environment (e.g., Green, Mooshaghian, Kaplan, Zaidel, & Iacoboni, 2009; Ristic & Kingstone, 2005). Also such orienting may be affected by information associated to the averted gaze such as age, social status, gender, and personal attitude of the seen person (e.g., Ciardo, Marino, Actis-Grosso, Rossetti, & Ricciardelli, 2014; Ciardo, Marino, Rossetti, Actis-Grosso, & Ricciardelli, 2013; Ciardo, Ricciardelli, Lugli, Rubichi, & Iani, 2015).

To note, it has been recently suggested that the cueing effects elicited by gaze and arrow cues could result from the conflict between the spatial information provided by the directional cue and the position of the target (Green & Woldorff, 2012; Green, Gamble, & Woldorff, 2013; see also Stevens, West, Al-Aidroos, Weger, & Pratt, 2008, for a similar account). For instance, Green et al. (2013) varied both cue duration (i.e. the amount of time the cue is presented) and cue-target intervals in nonpredictive gaze and arrow cueing tasks. Results showed that cueing effects occurred for long-duration cues only, when the cue and the target were simultaneously displayed on the screen or when the cue-target interval was shorter than 300 ms, and they consisted only of costs (slower RTs for incongruent trials compared to neutral trials). Based on these results, Green and colleagues (2013) proposed that cueing effects for long-duration cues at short cue-target intervals might not reflect attentional orienting, but might rather reflect a conflict emerging in incongruent trials between the spatial representations activated by the direction suggested by the cue and the location of the target (see also Stevens et al., 2008).

In the present study, we tested this latter hypothesis by exploring if gaze and arrow cueing effects behave in the same way as other effects emerging from a spatial conflict. Specifically, we focused on the Simon task (Simon & Rudell, 1967; for reviews see Proctor & Vu, 2006), in which participants are required to respond to a nonspatial feature (e.g., colour or shape) of a stimulus presented either to the left or to the right of fixation with a right or left key-press, while ignoring its location. The typical result is a faster and more accurate performance when stimulus and response locations spatially correspond as compared to when they do not correspond. This difference in performance between corresponding and noncorresponding trials (i.e., the Simon effect) is thought to emerge because stimulus location, even if task-irrelevant, is processed and brings to the automatic activation of the response that spatially corresponds to stimulus position (e.g., De Jong, Liang, & Lauber,

1994; Kornblum, Hasbroucq, & Osman, 1990). In corresponding trials, this automatically activated response corresponds to the one indicated by task instructions and, as a consequence, performance is more efficient. Differently, in noncorresponding trials, the automatically activated response and the response required by task instructions differ, and a conflict arises that causes a slowing of RTs and increased numbers of errors.

The conflict at the basis of the Simon effect has been widely investigated and several studies showed that the magnitude of the effect varies trial-by-trial as a function of correspondence sequence. Indeed, the effect reduces, disappears or even reverses following an incongruent trial, while it is always present following a congruent trial (e.g., D'Ascenzo, Iani, Guidotti, Laeng, & Rubichi, 2016; Iani, Rubichi, Gherri, & Nicoletti, 2009; Iani, Stella, & Rubichi, 2014; Hommel, Proctor, & Vu, 2004). These trial-by-trial modulations have been taken as evidence that the conflict experienced in a trial leads to adjustments aimed at preventing the recurrence of the conflict in the next trial (for a review see Mansouri, Tanaka, & Buckley, 2009; but see also Hommel, Proctor, & Vu, 2004 for an alternative account). These mechanisms, that may involve either the enhanced processing of task-relevant information (e.g., Egner & Hirsh, 2005) or the inhibition of task-irrelevant features (e.g., Braver 2012; Ridderinkhof, 2002), represent a form of reactive control.

The term reactive control is used to denote adaptations in the performance of a specific trial that are triggered by the conflict experienced in the previous trial (e.g., Botvinick, Braver, Barch, Carter, & Cohen, 2001; Braver, 2012). This form of control differs from a second form of control, defined as proactive control, which refers to the adjustments of task parameters and priority settings occurring prior to the occurrence of cognitively demanding events (Braver, 2012; Logan, 1985; see also Marini, Chelazzi, & Maravita, 2013). This preventive mechanism is thought to enter into play, for instance, when the proportion of

congruent trials in a task is manipulated and has the main goal of maintaining task goals active (Braver, 2012).

Orienting of attention mediated by gaze and arrow cues seems to be immune to proactive control. Indeed, previous studies demonstrated that at short cue-target intervals cueing effects occur even when the target is four times as likely to appear at the uncued location (Driver et al., 1999, Experiment 3; see also Bayliss & Tipper, 2006; Friesen, Ristic, & Kingstone, 2004). As regards reactive control mechanisms, the results of recent studies investigating trial-by-trial modulations with uninformative central cues showed larger cueing effects following a congruent than an incongruent trial for both arrows (Qian, Shinomori, & Song, 2012a, 2012b) and gaze (Qian, Feng, Shi, & Wang, 2014) cues only when the cue-target interval of the previous trial was long (700 ms). Qian et al. (2012a) interpreted these results, along with the observation that trial-by-trial modulations were evident irrespective of whether the cue was predictive or not, as consistent with the automatic memory check hypothesis according to which information encoded in a trial is automatically retrieved in the following trial (see Logan, 1988). In line with this view, they suggested that when the cue-target interval of the previous trial is long enough (>300 ms), the relationship between cue and target is encoded into memory and then automatically retrieved during the current trial at both short and long cue-target intervals, hence determining trial-by-trial modulations. When the cue-target interval of the previous trial is short (100 ms), due to the short perceiving time of the cue, either the cue-target relationship of the previous trial may not be encoded into memory, or the encoded relationship information may not be totally updated by the new relationship in the current trial (cf. Qian et al., 2014a). As a result, trial-by-trial modulations do not occur. According to this view, trial-by-trial modulations would depend on episodic encoding and/or retrieval processes rather than on strategic control.

Given the above considerations, the present study was aimed at assessing whether the conflict at the basis of the gaze cueing effect is spatial in nature by investigating whether it is influenced by the same trial-by-trial modulations that are typically reported in the Simon task, which is characterized by a spatial conflict. Specifically, in Experiment 1 we compared the trial-by-trial modulations emerging in the Simon task with those emerging in a gaze cueing task. To assess the potential influence of the biological relevance of the cue, in Experiment 2 we compared trial-by-trial modulations emerging with gaze and arrow cues. In order to focus on the spatial conflict hypothesis proposed by Green and colleagues (2012, 2013), we limited our investigation to cueing effects emerging for long-duration cues at cue-target intervals shorter than 300 ms (Green et al., 2012, 2013; Stevens et al., 2008). Specifically, we decided to use a cue-target interval of 200 ms, which is a crucial interval since in reflexive orienting longer cue-target intervals give rise to the inhibition of return (IOR) phenomenon (Klein, 2000; Posner & Cohen, 1984); that is taken as an additional marker of reflexive attentional orienting. More importantly, there is evidence showing that at 200-ms SOA (Stimulus Onset Asynchrony, or cue-target interval), gaze cues can trigger facilitation-without-cost suggesting that facilitatory effects emerge rapidly likely due to the earlier effects of automatic priming. It also seems that only at 300-ms SOAs or longer nonpredictive gaze cues with the eyes looking right, left, or straight ahead (the neutral directional cue) can trigger facilitation-plus-cost (see Heitanen, 1999; Langdon & Smith, 2005). To note, the fact that facilitation-plus-cost are evident only after 300 ms may depend on two factors. Namely, the sudden appearance of the central face can attract attention for some time and the direction of gaze in the face requires time to be perceived, thus one or both of these factors may cover up the costs. This is in line with a recent MEG study (Uonoa et al., 2014) showing that the superior temporal sulcus and the inferior frontal gyrus were commonly activated after 200 ms, in response to directional cues. Using a 200-ms SOA would also allow us to assess whether memory processes could be

responsible for cueing effects. Furthermore, since the realness of the neutral cue is debated, we decided not to include the neutral directional cue that would also have been difficult to compare to the conditions of the Simon task.

Our hypotheses were as follows. First, if cueing effects elicited by long-duration gaze and arrow cues are due to the conflict emerging between the spatial representations activated by the direction signalled by the cue and the location of the target (Green et al., 2012, 2013), then they should behave like the Simon effect. Specifically, the spatial conflict experienced in a trial should lead to adjustments aimed at preventing the recurrence of the spatial conflict in the next trial (Botvinick, et al. 2001; Braver, 2012; Mansouri, et al. 2009) by the enhancing the processing of task-relevant information (e.g., Egner & Hirsh, 2005) or by inhibiting task-irrelevant features (e.g., Braver 2012; Ridderinkhof, 2002). Thus, trial-by-trial modulations in the gaze and arrow cueing should show a similar pattern as those evident in the Simon task: following an incongruent trial, responses should be both i) slowed down for congruent trials and ii) speeded up for incongruent trials.

Second, in line with previous studies (e.g., Brignani et al., 2009; Galfano et al., 2012; Kuhn & Kingstone, 2009; Qian et al., 2012a, 2012b, 2014) showing that the attentional orienting profiles elicited by nonpredictive arrows and gaze cues are similar, we hypothesized that the biological relevance of the cue should not influence the occurrence of trial-by-trial modulations.

Experiment 1

Experiment 1 investigated whether trial-by-trial modulations occur in a gaze cueing task with a cue-target interval of 200 ms, and whether they resemble the modulations evident in a spatial conflict task such as the Simon task. In line with previous studies (e.g., Iani et al. 2009, 2014), we expected the Simon effect to be modulated by the correspondence of the

preceding trial, with a decreased or absent effect following a noncorresponding trial. If, as suggested by Green et al. (2012, 2013), cueing effects elicited by long-duration gaze cues are due to a conflict between the spatial representations activated by the direction signalled by the cue direction and the location of the target, then trial-by-trial modulations should be evident and should follow the same pattern as that reported for the Simon effect. Specifically, according to Green and colleagues (2012, 2013) who reported that at short cue-target intervals cueing effects associated with long-duration gaze cues consist only of costs, we hypothesized that trial-by-trial modulations should affect incongruent trials only.

To note, the majority of the studies investigating trial-by-trial modulations in gaze and arrow cueing employed detection tasks (e.g., Green et al., 2013; Qian et al., 2012a, 2012b, 2013). To the best of our knowledge, only one recent study by Qian and colleagues (Qian, Wang, Song, & Wang, 2017) used a discrimination task and found trial-by-trial modulations comparable to those observed when detection tasks are used. Since we were interested in comparing the trial-by-trial modulations evident in the Simon task (in which participants are required to discriminate target identity) with those evident in these cueing tasks, in the present study we decided to require a discrimination of target identity also in the cueing task.

Method

Participants

Thirty-two participants (6 males; 2 left-handed; Mean age: 26 ± 3.2 years) took part in the study. All participants had normal or corrected-to normal vision and were unaware of the purpose of the experiment. All gave their informed consent before participating. This and the following experiment were conducted in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and were approved by the Ethical Committee of the University of Milano-Bicocca.

Apparatus and Stimuli

The experiment was carried out in a dimly lit and noiseless room. The participant was seated facing a 15''monitor (1024 x 768) driven by a 2.08 GHz processor computer at a viewing distance of 60 cm. Stimulus presentation, response timing and data collection were controlled by the E-Prime version 2 software (Psychology Software Tools, Inc).

In the gaze cueing task, the stimulus was a grayscale photograph (7.98° × 15.76°) depicting a female young adult bearing a neutral expression (Productive Aging Lab Face Database; Minear and Park, 2004). Gaze direction was manipulated using Adobe Photoshop so the gaze could be averted 0.65° to the left or to the right. Responses were executed by pressing the "H" or the "SPACE" key on an Italian keyboard with the right and left index fingers, respectively. The choice of these key-press responses was made because it was in fact an up/down choice of keys and not a right/left one, regardless of the hand used. Therefore, we attempted to reduce the variance that might be produced by any S-R mapping that could have arisen if a left response had ever been required for a target letter appearing on the right, or vice versa (Driver et al., 1999).

In the Simon task, the stimuli were red and green solid squares (2° x 2°), presented to the left or to the right of fixation with an eccentricity of 5° (Figure 1, panel a). Responses were executed by pressing the "A" or the "L" key on an Italian keyboard with the left or the right index finger, respectively. For both tasks, the keyboard was located centrally with respect to the body midline.

Procedure

Participants performed individually in two consecutive sessions, separated by a 5-min interval and lasting about 60 minutes in total. Half of the participants performed the gaze

cueing task during the first session and the Simon task during the second one (tasks order: Gaze-Simon). The remaining participants performed the two tasks in the opposite order (tasks order: Simon-Gaze).

In the gaze cueing task, each trial began with the presentation of a white fixation cross (0.83°) in the centre of a black screen for 900 ms (fixation frame), followed by the central face with direct gaze (face frame). After 900 ms, the face appeared with averted gaze (cue frame). After 200 ms, a white target letter (L or T, 0.83°) appeared 10.8° to the left or right of the centre of the screen in one of two possible locations that could be spatially congruent or incongruent with gaze direction. The target frame remained visible until a response was provided (Figure 1, panel a). Gaze direction was uninformative of target location. Participants were explicitly instructed to respond according to the letter identity, while ignoring the distracting face, and to maintain fixation at the centre of the screen. Half of the participants were instructed to press the "H" key on the keyboard with the right hand if the target was the letter 'L', and the "SPACE" key with the left hand if the target was the letter 'T'. The remaining participants responded using the opposite stimulus-response mapping. Instructions emphasized both response speed and accuracy. No feedback was provided. The gaze cueing task consisted of 256 trials that were divided into four blocks preceded by 16 practice trials.

In the Simon task, participants were asked to respond as quickly and accurately as possible to the colour of the stimulus, ignoring its spatial location. Half of the participants responded to the red square by pressing the "A" key and to the green square by pressing the "L" key, and the other half experienced the opposite mapping rule. Each trial began with the presentation of a white fixation cross (0.83°) in the centre of a black screen for 1000 ms. Subsequently the stimulus was presented and remained present for 1000 ms, or until a response was made. The inter-trial interval was 1000 ms. Instructions emphasized both

response speed and accuracy and no feedback was provided. The Simon task consisted of 256 trials that were divided into four blocks preceded by 8 practice trials.

For both tasks, in each block, the trial sequence was controlled so that each trial was preceded by either a congruent/ corresponding (C) or an incongruent/ noncorresponding (NC) trial, with equal probabilities; this produced four different trials sequences (C–*C*, C–*NC*, NC–*C*, NC–*NC*, with italics denoting trial n)[1].

Insert Figure 1 about here

Results and discussion

The first trial of each block, responses that were preceded by an incorrect response and responses faster than 150 ms and slower than 1000 ms were excluded from the analysis (6.5 % and 5.5 % of the total trials for the gaze cueing and the Simon tasks, respectively).

Since a preliminary analysis showed that RTs in the two tasks were significantly different, data from the two tasks were analysed separately. For each task, mean correct reaction times (RTs) and arcsine-transformed error rates were submitted to two separate repeated measures Analyses of Variance (ANOVA) with *Trial n-1 Congruency/Correspondence* (Gaze cueing task: congruent vs. incongruent; Simon task: corresponding vs. noncorresponding) and *Trial n Congruency/Correspondence* (Gaze cueing task: congruent vs. incongruent; Simon task: corresponding vs. noncorresponding) as within-subject factors and *Task Order* (Gaze-Simon vs. Simon-Gaze) as a between-subjects factor. When necessary, comparisons were performed using paired samples *t* tests and by correcting

[1] In the present study, we employed a version of the Simon task that had previously been demonstrated to show strong trial-by-trial modulations, even when stimulus and response repetitions were controlled (Iani et al., 2009, 2014).

the *p* value for the number of comparisons (Bonferroni correction). The respective data for the two tasks are reported in Table 1.

Gaze cueing task

The analysis on RTs showed that responses were faster for congruent (M = 487 ms, SE = 9.99 ms) than for incongruent (M = 503 ms, SE = 9.71 ms) trials, as indicated by the main effect of *Trial n Congruency*, $F_{1,30}$ = 53.40, p < .001 , η_p^2 = .64. This effect was modulated by congruency sequence, as indicated by the significant interaction between *Trial n Congruency* and *Trial n-1 Congruency*, $F_{1,30}$ = 5.32, p = .03 , η_p^2 = .15. Post-hoc comparisons showed a 21-ms cueing effect after a congruent trial, $t_{1,31}$ = 6.70, $p_{\text{Bonferroni-corrected}}$ < .001, and a 12-ms cueing effect after an incongruent trial, $t_{1,31}$ = 4.20, $p_{\text{Bonferroni-corrected}}$ < .001. Paired simple t-test showed that the difference between the two effects was significant, $t_{1,31}$ = 2.33, p = .03 (see Figure 2, upper panel). Importantly, post-hoc comparisons revealed that the congruency of trial *n*-1 modulated RTs in the following congruent trials, with faster RTs when *n-1* was congruent (C–*C:* M = 483 ms, SE = 9.71 ms) than when it was incongruent (NC–*C:* M = 491 ms, SE = 10.55 ms), $t_{1,31}$ = 2.54, $p_{\text{Bonferroni-corrected}}$ = .04, but not in the following incongruent trials (C–*NC*: M = 504 ms, SE = 9.81 ms; NC–*NC*: M =503 ms, SE = 9.83 ms; $t_{1,31}$ < 1). No other main effect or interaction were significant, all *p*s > .12. No significant main effects or interaction emerged from the analysis on errors (4%, all *p*s > .11).

To investigate the influence of the repetition/alternation of target identity and target location on trial-by-trial modulations, we ran an ANOVA with *Trial n-1 Congruency* (congruent vs. incongruent)*, Trial n Congruency (*congruent vs. incongruent), *Target location* (repetition vs. alternation) and *Target identity* (repetition vs. alternation) as within-participant factors.

The analysis showed main effects of *Target location,* $F_{1,31}$ = 4.14, p = .05, η_p^2 = .12, and *Target identity,* $F_{1,31}$ = 9.25, p < .01, η_p^2 = .23, and a significant interaction involving the

two factors, $F_{1,31} = 108.30$, $p < .001$, $\eta_p^2 = .78$. Post-hoc comparisons showed that RTs were faster when both target location and target identity repeated ($M = 473$ ms, $SE = 9.45$ ms) or alternated ($M = 489$ ms, $SE = 10.25$ ms), while they were the slowest when either one of the two factors alternated (target position: $M = 507$ ms, $SE = 9.93$; target identity: $M = 514$ ms, $SE = 10.67$ ms). The interactions between *Target location* and *Trial n Congruency,* $F_{1,31} = 8.84$, $p < .01$, $\eta_p^2 = .22$, and between *Target identity* and *Trial n Congruency*, $F_{1,31} = 5.17$, $p < .05$, $\eta_p^2 = .14$, were significant. Post-hoc comparisons showed that the repetition/alternation of target position affected only incongruent trials, with faster responses when target position repeated ($M = 498$ ms, $SE = 9.71$) than when it alternated ($M = 509$ ms, $SE = 9.92$). No difference was evident for congruent trials (repetitions: $M = 488$ ms, $SE = 9.92$; alternations: $M = 486$ ms; $SE = 10.01$ ms). Repetition/alternation of target identity affected only congruent trials with faster RTs when target identity repeated ($M = 479$ ms, $SE = 9.87$ ms) as compared to when it alternated ($M = 496$ ms, $SE = 10.39$ ms). No difference was evident for incongruent trials (repetitions: $M = 501$ ms, $SE = 9.51$; alternations: $M = 507$ ms, $SE = 10.48$ ms). The interactions between *Target identity* and *Trial n-1 Congruency,* $F_{1,31} = 9.98$, $p < .01$, $\eta_p^2 = .24$, and between *Target position, Target identity,* and *Trial n-1 Congruency,* $F_{1,31} = 8.17$, $p < .01$, $\eta_p^2 = .21$, were significant. The interaction between *Trial n Congruency* and *Trial n-1 Congruency* was significant, $F_{1,31} = 5.76$, $p = .02$, $\eta_p^2 = .16$. Importantly, neither *Target identity* nor *Target position* modulated this interaction *(*all *p*s >.10). These results indicate that, even though the repetition/alternation of target identity and/or position affected performance, it did not influence trial-by-trial modulations.

Simon task

The analysis on RTs showed that responses were faster for corresponding ($M = 408$ ms, $SE = 9.38$ ms) than for noncorresponding ($M = 440$ ms, $SE = 8.47$ ms) trials, as indicated by the

main effect of *Trial n Correspondence,* $F_{1,30} = 47.02$, $p < .001$, $\eta_p^2 = .61$. This correspondence effect was modulated by correspondence sequence, as indicated by the significant interaction between *Trial n Correspondence* and *Trial n-1 Correspondence*, $F_{1,30} = 83.90$, $p < .001$, $\eta_p^2 = .74$. Post-hoc comparisons showed the typical sequential effects reported in previous studies (e.g., Iani et al., 2009, 2014) with a significant 59-ms Simon effect after a corresponding trial, $t_{1,31} = 11.68$, $p_{\text{Bonferroni-corrected}} < .001$, and a non-significant Simon effect (4 ms) after a noncorresponding trial, $t_{1,31} < 1$ (see Figure 2, upper panel). Importantly, post-hoc comparisons revealed that the correspondence of trial *n*-1 modulated RTs both in the following corresponding (C–*C*: *M* = 393 ms, *SE* = 8.37 ms; NC–*C*: *M* =424 ms, *SE* = 10.74 ms; $t_{1,31} = 7.15$, $p_{\text{Bonferroni-corrected}} < .001$) and noncorresponding trials (C–*NC*: *M* = 452 ms, *SE* = 9.35 ms; NC–*NC*: *M* =428 ms, *SE* = 8.26 ms; $t_{1,31} = 6.90$, $p_{\text{Bonferroni-corrected}} < .001$). No other main effect or interaction were significant, all *p*s > .08.

As regards errors (4.5%), the main effect of *Trial n Correspondence* was significant, $F_{1,30} = 15.01$, $p = .001$, $\eta_p^2 = .33$, with fewer errors in corresponding than in noncorresponding trials (1.7% vs. 3.0%, respectively). There was also a significant interaction between *Trial n Correspondence* and *Trial n-1 Correspondence,* $F_{1,30} = 48.88$, $p < .001$, $\eta_p^2 = .62$. After a corresponding trial, there was a significant Simon effect (3.1%; $t_{1,31} = 9.54$, $p_{\text{Bonferroni-corrected}} < .001$), whereas no effect was evident after a noncorresponding trial (0.5%; $t_{1,31} < 1$).

****Insert Table 1 about here****

The results of Experiment 1 showed that both the Simon effect and gaze cueing effect were modulated by the correspondence/congruency of the preceding trial. In the Simon task, a large Simon effect (59 ms) was evident following a corresponding trial, whereas no effect (4 ms, n.s.) emerged following a noncorresponding trial. The nonsignificant effect reported

following a noncorresponding trial resulted both from the slowing down of RTs for corresponding trials and the speeding up of RTs for noncorresponding trials compared to when the preceding trial was corresponding. A similar pattern of results was reported for errors, with a null Simon effect after a noncorresponding trial. Taken together, these results replicate those of previous studies (e.g., Iani et al., 2009, 2014) and support the idea that the detection of a conflict in trial *n*-1 triggers adaptations that are aimed at eliminating the impact of spatial S–R correspondence on response selection in the following trial (Braver 2012; Ridderinkhof, 2002).

In contrast with the results reported by Qian and colleagues (2012a, 2012b, 2014), the results from the present experiment showed that trial-by-trial modulations in the gaze cueing task occurred even when the cue-target interval of the previous trial was short. Indeed, the gaze cueing effect was larger (21 ms) after a congruent trial than after an incongruent trial (12 ms). However, in contrast with the pattern reported in the Simon task, trial *n-1* congruency modulated the gaze cueing effect by affecting congruent trials only, suggesting that at short cue-target intervals the delays reported by Green et al. (2012, 2013) for long-duration cues are immune to the trial-by-trial modulations that are typically found when the conflict is spatial in nature.

Experiment 2

The results of Experiment 1 indicate that trial-by-trial modulations occur in the gaze mediated orienting of attention but they do not resemble the modulations evident in the Simon task. In contrast with our predictions, the congruency of trial *n-1* modulated RTs in the following congruent trials but not in the following incongruent trials, suggesting that at short cue-target intervals the delays reported by Green et al. (2012, 2013) for long-duration cues are immune to trial-by-trial adaptations typically observed in spatial conflict tasks.

To note, in Experiment 1 the investigation of trial-by-trial modulations was limited to biological relevant cues (i.e., gaze direction). Thus, the different pattern of results reported for the Simon and the gaze cueing tasks could be due to the different nature of the stimuli used in the tasks (biologic vs. symbolic). To assess whether the biological relevance of the cue could play a role, in Experiment 2 we compared trial-by-trial modulations emerging in the gaze cueing task with those emerging in the arrow cueing tasks. In order to reduce the difference in the perceptual complexity (e.g., skin texture; see Hietanen & Leppänen, 2003) between biologic and symbolic cues, in Experiment 2 we used a schematic face instead of a real face. Based on the results of Experiment 1, we expected to find a larger cueing effect after a congruent trial than after an incongruent one. Moreover, in line with previous studies (e.g., Brignani et al., 2009; Galfano et al., 2012; Kuhn & Kingstone, 2009; Qian et al., 2012a, 2012b, 2014, 2017) showing that the attentional orienting profiles elicited by nonpredictive arrows and gaze cues are similar, we expected to find no difference in the trial-by-trial modulations between the two cue types.

Method

Participants

Thirty-two new participants (6 males; 4 left-handed; Mean age: 23 ± 2.7 years) selected as in the previous experiment, took part in Experiment 2. All participants gave their informed consent and the study was conducted in accordance with the ethical protocol applied in Experiment 1.

Apparatus, stimuli and procedure

The apparatus was the same as in Experiment 1 except for what follows. The stimulus in the arrow cueing task was an arrow (2.5° in length) pointing to the left or right of fixation (Figure

1, panel b), while the stimulus in the gaze cueing task was a schematic face (8.57º in diameter) with two eyes (2.27º in diameter), see Figure 1, panel c (Kunh & Benson, 2007; Kuhn & Kingstone, 2009). For both tasks, responses were executed by pressing the "H" or the "SPACE" key on an Italian keyboard located centrally with respect to the body midline. Participants performed in two consecutive sessions, separated by a 5-min interval, and lasting about 60 minutes. Half of the participants performed the arrow cueing task during the first session and the gaze cueing task during the second one (tasks order: Arrow-Gaze). The remaining participants performed the two tasks in the opposite order (tasks order: Gaze-Arrow).

The procedure of both tasks was the same as in the gaze cueing task of Experiment 1. Each task consisted of 256 trials that were divided into four blocks preceded by 16 practice trials. For both tasks, in each block, the trial sequence was controlled so that each trial was preceded by either a congruent (C) or an incongruent (NC) trial, with equal probabilities; this produced four different trials sequences (C–*C*, C–*NC*, NC–*C*, NC–*NC*, with italics denoting trial n).

Results and discussion

The first trial of each block, responses that were preceded by an incorrect response, and responses faster than 150 ms and slower than 1000 ms were excluded from the analysis (7.1 % and 7.0 % of the total trials for the arrow and the gaze cueing tasks, respectively).

Mean correct reaction times (RTs) and arcsine-transformed error rates (arrow cueing task =4.1%, gaze cueing task= 4.0%) were submitted to two separate repeated measures ANOVAs with *Distractor* (arrow vs. gaze), *Trial n-1 Congruency* (congruent vs. incongruent), and *Trial n Congruency* (congruent vs. incongruent) as within-subject factors and *Task Order* (Gaze-Arrow vs. Arrow-Gaze) as a between-subjects factor.

The analysis on RTs showed that responses were faster in congruent (M = 486 ms, SE = 11.94 ms) than in incongruent (M = 504 ms, SE = 12.75 ms) trials, as indicated by the main effect of *Trial n Congruency,* $F_{1,30}$ = 95.55, p < .001 , η_p^2 = .76, and after a congruent (M = 492 ms, SE = 12.04 ms) than after an incongruent (M = 498 ms, SE = 12.63 ms) trial, as indicated by the main effect of *Trial n-1 Congruency,* $F_{1,30}$ =16.99, p < .001 , η_p^2 = .35. The interaction between *Trial n Congruency* and *Trial n-1 Congruency* was also significant, $F_{1,30}$ = 4.94, p = .034 , η_p^2 = .14. Post-hoc comparisons showed a 21-ms cueing effect after a congruent trial, $t_{1,31}$ = 9.09, p $_{\text{Bonferroni-corrected}}$ < .001, and a 14-ms effect after an incongruent trial, $t_{1,31}$ = 5.94, p $_{\text{Bonferroni-corrected}}$ < .001 (see Figure 2, lower panel). Furthermore, post-hoc comparisons revealed that the congruence of trial *n*-1 modulated RTs in following congruent trials (C–*C*: M = 481 ms, SE = 11.67 ms; NC–*C*: M = 491 ms, SE = 12.32 ms; $t_{1,31}$ = 4.01, p $_{\text{Bonferroni-corrected}}$ < .001) but not in following incongruent trials (C–*NC*: M = 503 ms, SE = 12.50 ms; NC–*NC*: M =505 ms, SE = 13.05 ms; $t_{1,31}$ = 1.44, p $_{\text{Bonferroni-corrected}}$ > .05). Importantly, these results were evident with both distractors, as evidenced by the lack of an interaction involving the Distractor factor (all Fs < 1). No other main effect or interaction were significant, all ps > .28. As regards errors, no main effects or interaction reached significance (all ps > .11).

****Insert Table 2 and Figure 2 about here****

To investigate the influence of the repetition/alternation of target identity and target location on trial-by-trial modulations, we ran an ANOVA with *Trial n-1 Congruency* (congruent vs. incongruent)*, Trial n Congruency (*congruent vs. incongruent), *Target location* (repetition vs. alternation) and *Target identity* (repetition vs. alternation) as within-participant factors.

The analysis showed main effects of *Target position*, $F_{1,31} = 5.98$, $p < .05$, $\eta_p^2 = .16$, and *Target identity*, $F_{1,31} = 35.43$, $p < .001$, $\eta_p^2 = .53$. The interaction between the two factors was also significant, $F_{1,31} = 125.54$, $p < .001$, $\eta_p^2 = .81$. Post-hoc comparisons showed that, when target position repeated, RTs were faster when also target identity repeated (M = 474 ms, SE = 11.94 ms) as compared to when it alternated (M = 512 ms, SE = 13.22 ms), $t_{1,31} = 10.39$, $p_{\text{Bonferroni-corrected}} < .001$. When target position alternated, RTs did not differ as a function of the repetition/alternation of target identity (repetitions: M = 495 ms, SE = 12.88 ms; alternations: M = 500 ms, SE = 12.74 ms; $t_{1,31} = 1.68$, $p_{\text{Bonferroni-corrected}} > .05$). The main effects of *Trial n-1 Congruency,* $F_{1,31} = 14.79$, $p < .001$, $\eta_p^2 = .32$, and *Trial n Congruency*, $F_{1,31} = 81.29$, $p < .001$, $\eta_p^2 = .72$, were both significant, as was their interaction, $F_{1,31} = 4.34$, $p < .05$, $\eta_p^2 = .12$. The interaction between *Target identity* and *Trial n Congruency,* $F_{1,31} = 5.02$, $p < .05$, $\eta_p^2 = .14$, was significant. The three-way interaction involving *Target position*, *Target identity* and *Trial n-1 Congruency,* $F_{1,31} = 8.50$, $p < .05$, $\eta_p^2 = .22$, was significant. Post-hoc comparisons showed that when target location alternated, RTs for *n-1* congruent trials were faster than RTs for *n-1* incongruent trials, both when target identity repeated (*n-1* congruent: M = 489 ms, SE = 12.34 ms; *n-1* incongruent: M = 502 ms, SE = 13.59 ms; $t_{1,31} = 4.67$, $p_{\text{Bonferroni-corrected}} < .001$), than when it alternated (*n-1* congruent: M = 498 ms, SE = 12.78 ms; *n-1* incongruent: M = 502 ms, SE = 12.91 ms; $t_{1,31} = 4.14$, $p_{\text{Bonferroni-corrected}} < .001$). When target location repeated, RTs for *n-1* congruent trials were faster than RTs for *n-1* incongruent trials only when target identity repeated (*n-1* congruent: M = 469 ms, SE = 11.72 ms; *n-1* incongruent: M = 478 ms, SE = 12.40 ms; $t_{1,31} = 2.70$, $p_{\text{Bonferroni-corrected}} < .05$), while no difference was evident when target identity alternated (*n-1* congruent: M = 514 ms, SE = 13.35 ms; *n-1* incongruent: M = 510 ms, SE = 13.37 ms; $t_{1,31} < 1$). No other difference reached significance. The four-way interaction involving *Target position*, *Target identity*, *Trial n-1 Congruency* and *Trial n Congruency* did not reach significance ($F < 1$). As in Experiment 1,

even though the repetition/alternation of target identity and /or position affected performance, it did not influence trial-by-trial modulations.

Experiment 2 was aimed at testing if the results found in Experiment 1 were influenced by the biological relevance of the central cue. To this end, we compared the trial-by-trial modulations emerging when gaze and arrows were used as noninformative cues. In line with the results of Experiment 1, both gaze and arrow cueing effects were modulated by the congruence of the preceding trial. Again, results showed a larger cueing effect (21 ms) after a congruent trial than after an incongruent trial (14 ms). Such a result confirms that trial-by-trial modulations occur for gaze and arrow cues also when the cue-target interval of the previous trial is short. As in Experiment 1, results showed that trial *n-1* congruency affected congruent trials only. Interestingly, the magnitude of the cueing effect was comparable across the two experiments, even though in Experiment 2 schematic faces were used. Altogether, these results suggest that neither the biological relevance of the cue nor the repetition/alternation of target identity and/or position influenced trial-by-trial modulations.

General Discussion

Recent findings suggested that the cueing effects elicited by nonpredictive long-duration gaze cues could result from the conflict emerging in incongruent trials between the spatial information provided by the directional cue and the location of the target (Green at al., 2012, 2013; Stevens et al., 2008). In the present study we tested this hypothesis by investigating whether trial-by-trial modulations observed in a task characterized by a spatial conflict, the Simon task, occur in the gaze (Experiment 1) and in the arrow (Experiment 2) cueing tasks and whether they show the same pattern.

In Experiment 1, we compared trial-by-trial modulations in the gaze cueing task with those evident in the Simon task. We hypothesized that if the gaze cueing effect emerging for

long duration cues at short cue-target intervals is due to a conflict arising between the spatial representations activated by the cue and by the target (Green et al., 2012, 2013; Stevens et al., 2008), then trial-by-trial modulations should show a similar pattern as those evident in the Simon task with a speeding up of incongruent responses and a slowing down of congruent responses after an incongruent trial.

The results of Experiment 1 showed that both the Simon effect and gaze cueing effect were modulated by the correspondence/congruency of the preceding trial. However, these modulations took different forms. Specifically, in the Simon task, corresponding responses were faster following a corresponding trial than a noncorresponding one and noncorresponding responses were faster following a noncorresponding trial than a corresponding one. Differently, in the gaze cueing task, the congruency of the preceding trial modulated RTs in the following congruent trials only, with faster RTs when the preceding trial was also congruent compared to when it was incongruent. The results of Experiment 1 were replicated in Experiment 2, in which we compared trial-by-trial modulations in the gaze and the arrow cueing tasks and schematic faces were used instead of pictures of real faces. This finding suggests that the cueing effects reported by Green et al. (2012, 2013) for long-duration cues at SOA shorter than 300 ms are not subject to those trial-by-trial modulations that are typically reported in spatial conflict tasks (e.g. Iani et al., 2009, 2014).

Previous studies showed that trial-by-trial modulations occur in both exogenous (Mordkoff, Halterman, & Chen, 2008) and endogenous (Jogen & Smulders, 2006) orienting tasks. For instance, Mordkoff et al. (2008, main experiment) showed that trial-by-trial modulations for exogenous orienting of attention in a detection task were evident at a short cue-target interval (50 ms) and took the form of faster RTs when two valid trials occurred in succession, this resulting in a larger cueing effect following a valid trial than an invalid one (27 ms vs. 10 ms for the condition when only two display locations were used). To explain

this result, the authors proposed that the validity of the previous trial determined whether attention could be captured by the cue, hence suggesting that previous cue validity could exert a modulating effect on attentional capture.

Trial-by-trial modulations have been reported also for endogenous orienting of attention. For instance Jogen and Smulders (2006), by using cues with a predictive validity of either 80 or 50% to have valid, invalid and neutral trials and a cue-target interval of 900 ms, found a larger cueing effect when the previous trial was valid (60 ms) as compared to when it was invalid (40 ms). This result was due to a reduction of both costs (the difference in RTs between invalid and neutral trials) and benefits (the difference in RTs between valid and neutral trials) following an invalid trial. Based on these results they proposed that trial-by-trial modulations observed in endogenous orienting represent strategic adjustments, similar to those observed in other conflict tasks, such as the Eriksen (Eriksen & Eriksen, 1974; see Gratton et al., 1992) and Simon tasks.

Differently from the study by Jogen and Smulders (2006), we used nonpredictive central cues (gaze or arrows) with a cue-target interval of 200 ms and required participants to discriminate target identity. Similarly to Mordokoff et al.'s results (2008), we found that validity/congruence sequence affected congruent trials only. There could be two possible explanations for this pattern of results. First, the observed modulations could be due to the slowing-down of congruent responses following an incongruent trial, possibly due to the suppression of attention orienting toward the location suggested by the central cue. Second, they could be due to the speeding-up of congruent responses following a congruent trial. Such an effect could be explained in terms of reward-based attentional learning (e.g., Chelazzi, Perlato, Santandrea, & Della Libera, 2013). In other words, attentional orienting toward visual stimuli may depend on the consequences deriving from their processing. Thus, the facilitation produced by following the direction of the task-irrelevant cue in a congruent

trial might lead to encode the distractor as a reward stimulus. As a consequence, in the subsequent trial participants might have used the rewarding consequences experienced in the prior trial and might have repeated the same behaviour, i.e. orienting attention in the direction signalled by the task-irrelevant cue. A previous rewarded cue would also allow orienting of attention in the next trial to be initiated faster than previous unrewarded cues (e.g., Fecteau & Munõz, 2003).

It could be argued that, since we did not include a neutral condition, we cannot discriminate between these two explanations. However, we do not believe the first explanation could apply to our results. Indeed, if this explanation were true, we should have found a modulation by congruence sequence also on incongruent trials. The observation that only congruent trials were affected by previous cue validity, with faster responses when two congruent trials were presented in succession, seems to be more in line with a reward-based explanation.

As regards our choice not to include neutral trials, we would like to point out that previous studies that included neutral conditions to investigate symbolic cueing effects in terms of cost and benefits reported controversial results (e.g., Friesen & Kingstone, 1998; Friesen, Ristic, & Kingstone, 2004; Frischen & Tipper, 2004) hence underlining that it can be challenging to establish a truly neutral condition for directional cues that are presented centrally. When gaze direction is used as a cue, the typical neutral condition consists of a face presented with straight gaze or closed eyes. However, these conditions lack in presenting a gaze shift as it occurs for congruent and incongruent trials. For this reason, and in line with most of the studies that have examined orienting patterns elicited by gaze and arrow cues (e.g., Bayliss and Tipper, 2006; Galfano et al., 2012; Gayzur et al., 2014; Tipples, 2002), we did not included a neutral condition.

It should be acknowledged that the observation that trial-by-trial modulations occur also for nonpredictive central cues (Qian et al., 2012a, 2012b, 2014) and even when the task requires a discrimination of target identity (Qian et al., 2017) is not new. Indeed, Qian et al. (2012a) investigated whether trial-by-trial modulations for nonpredictive arrow cues are influenced by the cue-target SOA of current and previous trial. They found a larger cueing effect following a valid/congruent trial, indicative of trial-by-trial modulations. However, these modulations were evident only when the cue-target SOA of the previous trial was long (700 ms), irrespective of the SOA of the current trials. Modulations were not evident when the SOA of the previous trial was short (100 ms). Such a result was obtained also when gaze was used as nonpredictive cue (Qian et al., 2014, 2017). According to the authors, the observation of trial-by-trial modulations even when nonpredictive central cues are used speaks against an explanation in terms of strategic adjustments and seems to support an explanation in terms of automatic memory processes, with the influence of cue-target SOA reflecting the timing of these processes. According to this view, and also in line with the *feature-integration* account proposed by Hommel et al. (2004; see also Hommel, 2004), the co-occurrence of cue and target in a given trial leads to the integration of their features and to the encoding of their relation (congruent vs. incongruent). This representation would be automatically reactivated in the following trial leading to better performance when the same relation is repeated as compared to when it alternates. As a result, following a congruent trial, RTs should be speeded up for congruent trials and slowed down for incongruent trials, leading to an increased cueing effect. Differently, following an incongruent trial, RTs should be speeded up for incongruent trials and slowed down for congruent trials, leading to a decreased cueing effect.

As regards the effect of cue-target SOA, the authors suggested that when the cue-target interval of the previous trial is long enough (>300 ms), the relationship between cue and

target is encoded into memory and then automatically retrieved during the current trial at both short and long cue-target intervals, hence determining trial-by-trial modulations. When the cue-target interval of the previous trial is short (100 ms), due to the short perceiving time of the cue, either the cue-target relationship of the previous trial may not be encoded into memory, or the encoded relationship information may not be totally updated with the new relationship in the current trial (cf. Qian et al., 2014a). As a result, trial-by-trial modulations do not occur.

Differently from Qian et al. (2012a, 2014, 2017), we found that trial-by-trial modulations of both gaze and arrow cueing effects occurred even when the cue-target interval of the previous trial was short. Since we used a 200 ms interval, it is possible that this interval was sufficient to allow for the encoding into memory of the cue-target relationship, hence producing trial-by-trial modulations. Our data, however, clearly indicated that congruence sequence did not affect incongruent trials but only congruent trials. Indeed, RTs for incongruent trials did not differ as a function of repetition/alternation of the cue-target relation from one trial to the subsequent one, as predicted by the memory account. In addition, our results indicated that trial-by-trial modulations were not affected by the repetition/alternation of target identity and/or position.

The finding that incongruent trials were not affected by the congruence of the previous trial is also in contrast with the proposal that at short cue-target intervals cueing effect for long-duration cues result from the conflict between the spatial information conveyed by the cue and the target (Green et al., 2012, 2013; Stevens et al., 2008). Indeed, if this was the case, in line with the results from the Simon task, the detection of a spatial conflict in trial *n*-1 should have triggered adaptation mechanisms aimed at eliminating the impact of the task-irrelevant information in the following trial (Braver 2012, Ridderinkhof, 2002), hence reducing the cueing effect. The fact that trial *n-1* congruency did not affect performance in

the subsequent incongruent trials is in line with the idea that orienting of attention driven by averted gaze might derive from an automatic mirror-like activation (e.g., Ricciardelli et al., 2002, 2013; see also Shepherd, Klein, Deaner, & Platt, 2009). Using an oculomotor task, Ricciardelli and colleagues (2002, 2013) showed that perceiving a gaze shift interfered with the execution of instructed saccades more often when the direction of the instructed saccade and the direction of the cue were in conflict. Accordingly, in our study the lack of influence of trial *n-1* congruency on incongruent trials can be interpreted as a failure of an inhibitory mechanism in suppressing the automatic and mirror-like oculomotor program induced by the gaze cue, even following a conflicting event. A similar explanation can be applied for arrows cueing effects. Indeed, as over-learned directional cues, arrows can cause the programming of an eye movement in the indicated direction, although it is likely to be easier to inhibit than the eye movement triggered by gaze direction (e.g., Marino, Mirabella, Actis-Grosso, Bricolo, & Ricciardelli, 2015). Moreover, our results are in line with a recent study by Gayzur et al. (2014), who reported evidence that reflexive orienting in response to central gaze cues is not affected by cue duration.

In line with previous studies (Qian et al., 2012a, 2012b, 2014) no difference was found in trial-by-trial modulations between arrows and gaze cues, suggesting that they produce a similar interference effect when they are incongruent with target location (Brignani et al., 2009; Galfano et al., 2012; Kuhn & Kingstone, 2009). Taken together the results of the present study are in line with the *symbolic automated orienting* account proposed by Ristic and Kingstone (2012) according to which overlearned directional cues might engage reflexive orienting of attention acting independently and in parallel with the two classic exogenous and endogenous mechanisms. Thus, when an uninformative overlearned directional cue is presented, spatial attention is rapidly, unintentionally, and automatically directed toward the signalled location. Our results support this idea by showing that, at short

cue-target intervals, cueing effects elicited by long-duration gaze and arrow cues are affected by trial-by-trial modulations similarly to what reported for exogenous orienting of attention.

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Disclosure of interest

The authors report no conflicts of interest.

TABLES

Table 1. Experiment 1: Mean correct reaction times (and standard error) in ms as a function of Task, Trial *n-1* (congruent/corresponding, C vs. incongruent/noncorresponding, NC), and Trial *n* (congruent/corresponding, C vs. incongruent/noncorresponding, NC). The Gaze Cueing Effect (GCE) is computed as the difference in RTs between incongruent and congruent trials, while the Simon Effect (SE) is computed as the difference in RTs between noncorresponding and corresponding trials.

Gaze Cueing Task				Simon task			
	Trial n				Trial n		
Trial n-1	C	NC	GCE	Trial n-1	C	NC	SE
C	483 (10)	504 (10)	21	C	393 (8)	452 (9)	59
NC	491 (11)	503 (10)	12	NC	424(11)	428 (8)	4

Table 2. Experiment 2: Mean correct reaction times (and standard error) in ms as a function of Distractor (gaze vs. arrow), Trial *n-1* (congruent/corresponding, C vs. incongruent/noncorresponding, NC), and Trial *n* (congruent/corresponding, C vs. incongruent/noncorresponding, NC). The Gaze Cueing Effect (GCE) and the Arrow Cueing Effect (ACE) are computed as the difference in RTs between incongruent and congruent trials.

Gaze cues				Arrow cues			
	Trial n				Trial n		
Trial n-1	C	NC	GCE	Trial n-1	C	NC	ACE
C	482 (13)	505 (13)	23	C	480 (12)	500 (13)	20
NC	492 (14)	504 (14)	12	NC	490 (12)	506 (13)	16

FIGURES

Figure 1. Illustration of the cueing task depicting examples of stimuli, and sequence of events, for a congruent trial *n* (highlighted in blue) preceded by an incongruent trial *n-1* (highlighted in red). Panel a. depicts procedure and stimuli used for the gaze cueing task in Experiment 1. Panels b. and c. depict procedure and stimuli used for the gaze and arrow cueing tasks in Experiment 2.

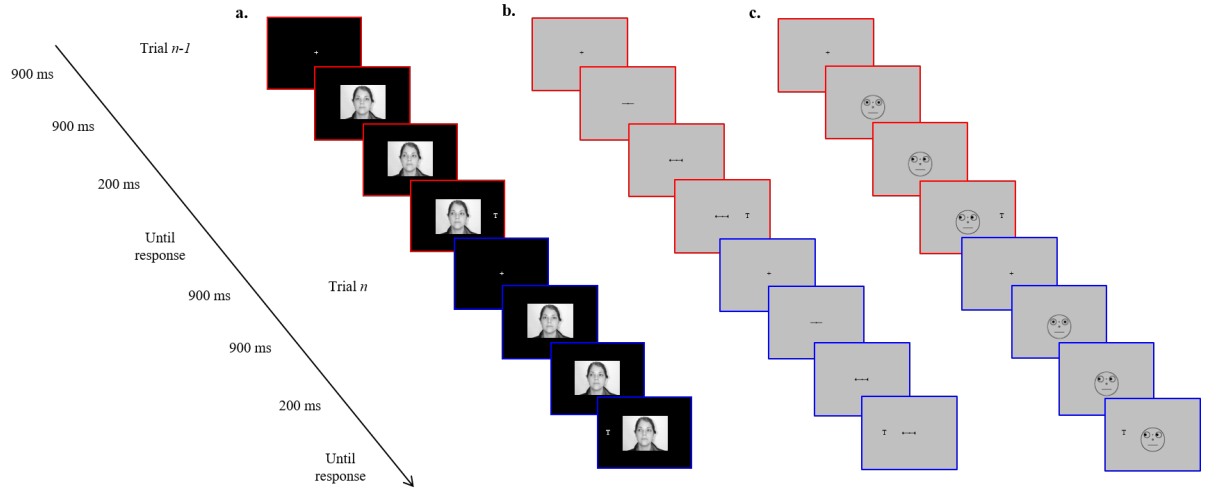
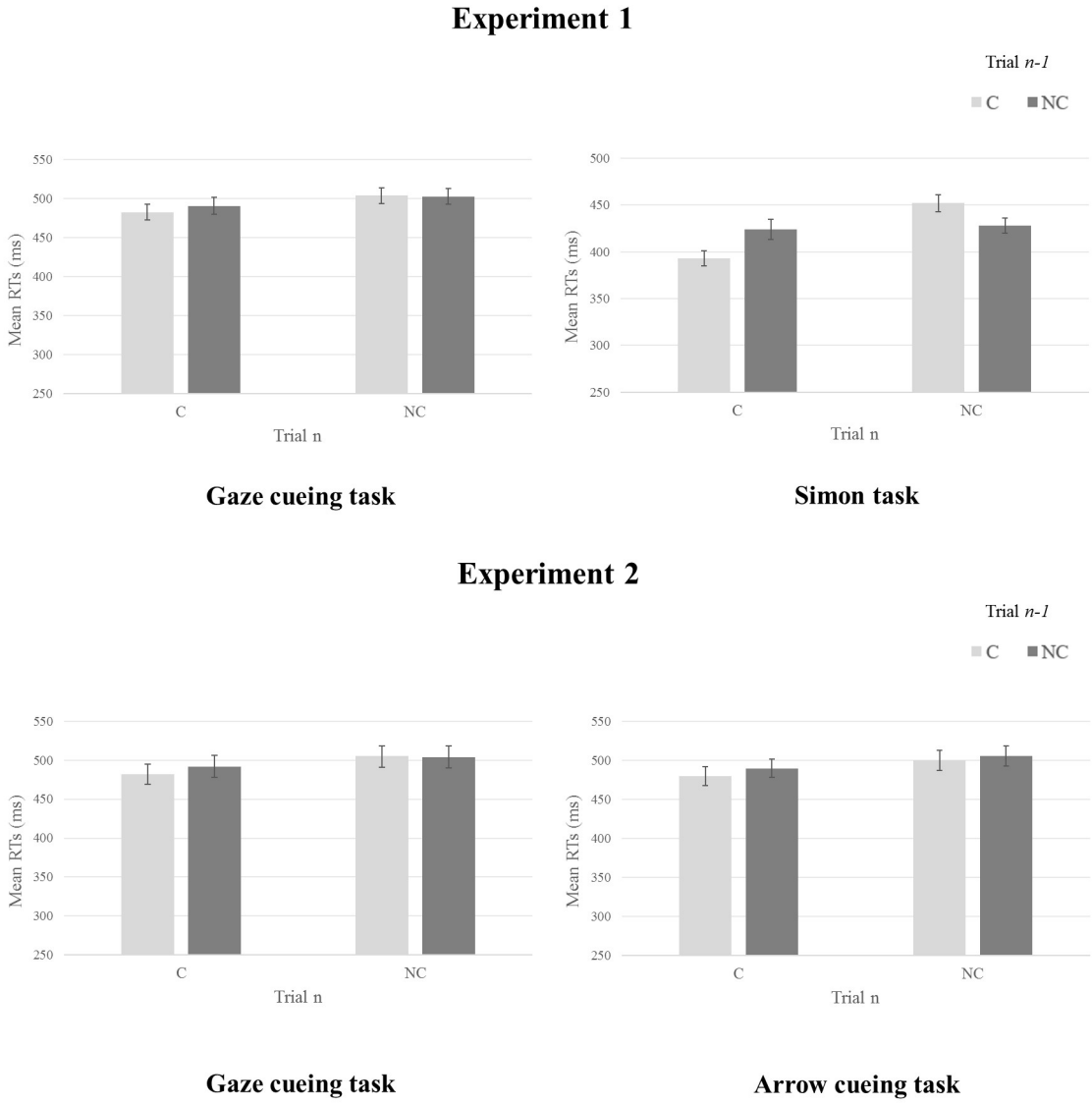
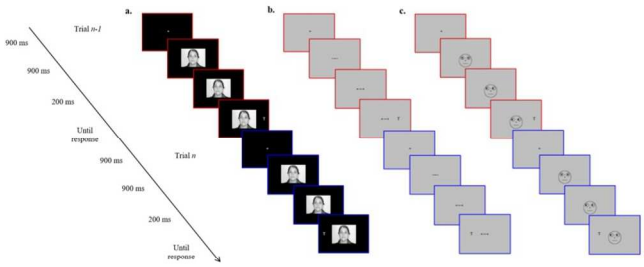


Figure 2. Mean reaction times in Experiment 1 (upper panel) and Experiment 2 (lower panel) for congruent/corresponding (C) and incongruent/noncorresponding (NC) Trial *n-1*, as a function of Trial *n* correspondence/congruence (C, NC). Error bars indicate standard errors of the mean.





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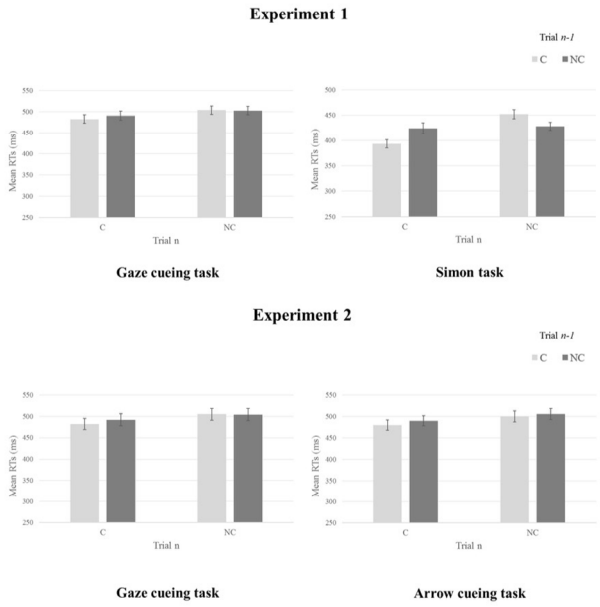

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