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Arrows don't look at you: Qualitatively different attentional mechanisms triggered by Gaze and Arrows

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4 **Arrows don't look at you: Qualitatively different attentional mechanisms**
5 **triggered by Gaze and Arrows**
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Abstract

Eye-gaze conveys rich information concerning the state of mind of others, playing a critical role in social interactions, signalling internal states, and guiding others' attention. On the basis of its social significance, some researchers have proposed that eye-gaze may represent a unique attentional stimulus. However, contrary to this notion, the majority of literature has shown undistinguishable attentional effects when eye-gaze and arrows are used as cues. Taking a different approach, this study aimed at finding qualitative attentional differences between gaze and arrow, when they are used as targets instead of as cues. We used a spatial Stroop task, in which participants were required to identify the direction of eyes or arrows presented to the left or right of the fixation point. Results showed that the two types of stimuli led to opposite spatial interference effects, with arrows producing faster reaction times when the stimulus direction was congruent with stimulus position (typical spatial Stroop), and eye-gaze producing faster reaction times when it was incongruent ("reversed" spatial Stroop). This reversed Stroop is interpreted as an eye-contact effect, therefore revealing the unique nature of eyes as special social-attention stimuli.

Keywords: Gaze, Arrows, Attention, Spatial Stroop

Introduction

Others' gaze constitutes an essential medium through which humans can communicate socially relevant information such as their focus of interest, private thoughts and intentions (e.g., Baron-Cohen, Weelwright, & Jolliffe, 1997). Visual attention is also deeply modulated by eye-gaze (e.g., Frischen, Bayliss, & Tipper, 2007) and our ability to attend the same object as an observed individual serves as a foundation for more sophisticated social skills such as a theory of mind, language acquisition and cultural learning (Tomasello, 1995). Indeed, averted-gaze stimuli can produce both covert (e.g., Driver et al., 1999) and overt (e.g., Kuhn & Benson, 2007) attentional orienting, whose magnitude is modulated by the social salience of these stimuli (e.g., Dalmaso, Galfano, & Castelli, 2015).

Direct gaze can also impact onto several cognitive and attentional mechanisms (i.e., the "eye contact effect"; Senju & Johnson, 2009), presumably due to the salience associated with such an indicator of being attended to. For examples, direct gaze can improve face processing (Macrae, Hood, Milne, Rowe & Mason, 2002), increase arousal in the recipient of gaze (e.g. Conty et al., 2010), and signal approach (Hietanen, Leppänen, Peltola, Linnaaho & Ruuhiala, 2008).

On the basis of these findings, it has been argued that attention to eye gaze may represent a unique attentional process and reflect the operation of a specialized cognitive mechanism. Thus, in the last years, to evaluate the uniqueness of the eye-gaze, many studies have tried to dissociate gaze attentional mechanisms from the attentional mechanisms engaged by symbolic directional stimuli such as arrows. However, although a variety of research strategies has been used, no general agreement has yet been achieved and some authors (e.g., Santiesteban et

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3
4 al., 2014), observing very similar effects for gaze and arrows, have proposed that
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6 gaze attentional effects are at least partially driven by a domain-general
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8 attentional process.
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11 Thus, an initial comparison between gaze and arrow cues has shown that
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13 eye-gaze cues are more resistant to voluntary control (Friesen, Ristic, &
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15 Kingstone, 2004). In particular, Friesen et al., (2004) used a so-called counter-
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17 predictive cueing paradigm (the target was more likely to appear in the location
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19 opposite the one indicated by the cue) and showed that a better performance at the
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21 indicated location was only observed when eye gaze was used as cue, but not
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23 when the indicated location was cued by an arrow. In contrast, when counter-
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25 predictive cueing was tested with arrows, participants' attention did not shift to the
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27 cued locations. However, in a more recent study using the same counterpredictive
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29 paradigm, Tipples (2008) found that both eye and arrow cues produce similar
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31 reflexive shifts of attention.
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35 Similarly, different overt orienting (involving eye movements) of attention
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37 for central gaze cues and arrow cues has been shown in one study (Ricciardelli et
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39 al., 2002), while subtle or no differences have been shown in others (Kuhn &
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41 Benson, 2007; Kuhn & Kingstone 2009). Taken together, these results seem to
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43 suggest that gaze produce attentional effects that do not differ substantially from
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45 those produced by arrow cues.
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49 Recently, however, using a more powerful “qualitative” approach several
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51 authors have found clear dissociations between gaze and arrow attentional effects.
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53 The logic here is that the attentional differences between gaze and arrow cues
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55 might be regarding the nature rather than the size of the attentional modulation
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4 induced by each cue type. For example, by using a variant of the double-rectangle
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6 task, Marotta, Lupiáñez, Martella, and Casagrande (2012) showed that attention
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8 spread to the entire cued object when arrows were used as cues, while it was
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10 selectively directed to the specific location or part of the object looked at, when
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12 gaze cues were used. Moreover, Bayliss, Paul, Cannon, and Tipper (2006) found
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14 that objects that are looked at by other people are more likable than those that do
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16 not receive much attention from others. This affective preference for cued objects
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18 was not found when arrows cues were used. Finally, combining a traditional gaze
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20 cueing paradigm with a visual memory task, Dodd, Weiss, McDonnell, Sarwal,
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22 and Kingstone (2012) and Gregory and Jackson (2017) have recently shown that
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24 gaze cues but not arrow cues improved memory accuracy for cued information.
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28 Although the dissociations between gaze and arrow cues described above
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30 are consistent with the view that eye gaze represents a unique and special
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32 attention cue, there is a weakness in the overall pattern of findings that is
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34 noteworthy; namely the absence of an effect for a particular type of cue could
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36 reflect a lack of sensitivity of the experimental procedure rather than a real
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38 difference between gaze and arrow cues. Ideally, powerful dissociation would
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40 involve a single task in which participants' performance is modulated in opposite
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42 ways by gaze and arrow cues.
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46 Seeking this type of qualitative double dissociation, the present study
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48 aimed at evaluating how gaze and arrows leads to spatial interference in response
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50 selection. One of the main tools to study the influence of irrelevant spatial
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52 information on performance is the spatial Stroop task (see Lu & Proctor, 1995, for
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54 a review). In its most used variant (Funes, Lupiáñez & Milliken, 2007; Pires,
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4 Leitao, Guerrini, & Simoes, 2017), a directional arrow is randomly presented to
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6 the left or right side of a fixation point and participants are required to
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8 discriminate the direction of the arrow while ignoring its location. Results have
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10 generally shown faster and more accurate responses to congruent stimuli (i.e., a
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12 right-pointing arrow presented on the right) than to incongruent ones (i.e., a left-
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14 pointing arrow presented on the right). However, in a recent study, using a variant
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16 of the spatial Stroop paradigm in which eye-gaze were used as stimuli, Cañadas
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18 and Lupiañez (2012) found a reversed congruency effect with faster reaction time
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20 to incongruent stimuli (i.e. a face looking to the left, presented on the right).
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22 Although these findings suggest the existence of an important dissociation
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24 between gaze and arrow stimuli, it constitutes a dissociation between different
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26 task contexts and experimental settings. Task differences make it difficult to
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28 directly compare the effects produced by the two types of stimuli. For this reason,
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30 the present study sought to directly compare the influence on performance of gaze
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32 and arrow stimuli in a context of the spatial Stroop task.
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36 Consistent with the majority of the findings obtained in the literature (Funes et al.,
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38 2007; Pires et al., 2017), we expected arrow stimuli to produce a typical spatial
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40 Stroop effect, with faster RT for congruent than for incongruent stimuli. If gaze
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42 stimuli were also to produce spatial Stroop interference, then this result would
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44 favor the domain-general attentional process view. In contrast, if, consistently
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46 with our predictions, gaze stimuli were to produce an effect that is opposite to the
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48 spatial Stroop effect, i.e., faster RT for incongruent stimuli, then this result would
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50 be strongly consistent with the view that eye gaze represents a unique and special
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52 attentional stimulus.
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METHOD

Participants

Informed consent was obtained from 36 students (27 women), with a mean age of 20.64 years, from the University of Granada. They received partial course credit for participating. All had self-reported normal or corrected-to-normal vision and were naïve as to the purpose of the experiment. We estimated the required sample size assuming a significance level of .05 and a power of 0.8, taking as a reference the effect size obtained in Jones (Experiment 1, 2015).

Apparatus and stimuli

Stimuli presentation, timing, and data collection were controlled by a program written using E-prime 2.0 run on a standard Pentium 4 PC. Stimuli were presented on a 17'' widescreen monitor with a 1,024 × 768 pixel resolution. They consisted of a 1 x 4 cm two black arrows display and full color cropped eyes on a gray rectangle (see Figure 1). Cropped eyes were obtained by manipulating an original face (taken from the MacBrain Face Stimulus Set; <http://www.macbrain.org/faces/index.htm>)¹ with Adobe Photoshop CS.

Procedure

¹ Face stimulus was drawn from the MacBrain Face Stimulus Set developed by Nim Tottenham and supported by the John D. and Catherine T. MacArthur Foundation Research Network on Early Experience and Brain Development. Please contact Nim Tottenham at tott0006@tc.umn.edu for more information concerning the stimulus set

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4 Participants were seated at approximately 60 cm from the computer screen
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6 in a faintly lit room to perform the experimental task. They were required to
7
8 perform a discrimination task in which they had to respond as fast and accurately
9
10 as possible to the direction (left or right) indicated by eye gaze or arrows. The
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12 experiment was composed of two halves (one for each target type), each one
13
14 composed of 15 practice trials followed by two experimental blocks of 64 trials
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16 each. Target direction and target location were randomly selected within each
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18 block of trials. The target types (gaze/ arrow) were separated in different halves of
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20 the experiment, with the order counterbalanced across participants.
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24 Each trial (see FIGURE 1) began with a white fixation cross presented in
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26 the center of a black screen for 1 second. Participants were instructed to fixate the
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28 cross. Then, a pair of eyes or arrows looking/pointing to the right or to the left was
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30 presented either to the left or to the right of the fixation cross for 2 seconds. The
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32 distance from the centre of the lateral stimulus to the central fixation cross was 5
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34 cm. Participants were instructed to press the “Z” key in response to the targets
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36 indicating the left, and the “M” key in response to targets indicating the right,
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38 independent of the target’s location. Feedback to incorrect key presses was
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40 provided to participants by presenting a 220-Hz tone for 1500 ms.
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44 Importantly, this design produced trials that were congruent (i.e., a right-
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46 indicating target presented on the right) or incongruent (i.e., a left-indicating
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48 target presented on the right).
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51 [INSERT FIGURE 1 ABOUT HERE]
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53 **Design**

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4 The experiment had a two-factor repeated measure design, with 64
5 observations per experimental condition. Target type had two levels: gaze and
6 arrow. Trial type had two levels: congruent and incongruent trials. Partial
7 ANOVAs were conducted for the analysis of interactions. For each participant,
8 mean RTs and accuracy (mean percent errors) were calculated for each
9 experimental condition.
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20 RESULTS

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22 As in Cañadas and Lupiáñez (2012), RTs faster than 200 ms (0.13% of
23 trials) or slower than 1300 ms (0.56%) and trials with an incorrect response
24 (6.45%) were excluded from the RT analysis. The data of one participant was
25 removed prior to analysis because the accuracy rate in two of the four blocks was
26 50%, and inspection of the responses revealed that this participant had been
27 tapping an incorrect key. Table 1 shows the mean (\pm SD) of RTs and percentage of
28 errors for each experimental condition.
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38 Reaction Times

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40 The ANOVA performed on mean RTs showed a main effect for Target
41 Type, $F(1, 34) = 133.52$, $p < .001$, $\eta_p^2 = 0.80$, with faster RTs for the arrow targets
42 compared to the gaze targets (508 ms vs. 588 ms). The main effect of Trial Type
43 was not significant, $F(1, 35) < 1$, $p = .553$, $\eta_p^2 = .01$. Importantly, the critical Target
44 Type by Trial Type interaction was significant, $F(1, 34) = 39.76$, $p < .001$, $\eta_p^2 =$
45 0.54, (Figure 2). Partial ANOVAs on each target type showed that RTs were
46 significantly longer on incongruent trials (519 ms) than on congruent trials (497
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ms) when arrows were used as targets condition, $F(1, 34) = 17.59$, $p < .001$, $\eta_p^2 = .34$; in contrast RTs were significantly faster on incongruent trials (580 ms) than on congruent trials (597 ms) when eye-gaze was used as target, $F(1, 34) = 8.26$, $p = .007$, $\eta_p^2 = .20$.

Errors

Neither the main effect of Target Type, $F(1, 34) < 1$, $p = .885$, $\eta_p^2 < .01$, nor the main effect of Trial Type, $F(1, 34) = 1.09$, $p = .304$, $\eta_p^2 = .03$, were significant. However, of relevance for the present study, the Target Type \times Trial Type interaction was significant, $F(1, 34) = 6.61$, $p = .015$, $\eta_p^2 = 0.71$. It is important to note that the error data were in the same direction as RT: in the arrow target condition, participants made more errors on incongruent than on congruent trials, $F(1, 34) = 9.20$, $p = .005$, $\eta_p^2 = .21$, while in the gaze target condition made more errors on congruent than on incongruent trials, although this difference was not significant, $F(1, 34) < 1$, $p = .427$, $\eta_p^2 = .02$.

[INSERT TABLE 1 AND FIGURE 2 ABOUT HERE]

Discussion

In the present study, we observed that eye-gaze and arrow stimuli led to

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4 opposite spatial interference effects, with arrows producing faster reaction times
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6 when the arrow direction was congruent with its position (typical spatial Stroop),
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8 and eye-gaze producing faster reaction times when it was incongruent (“reversed”
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10 spatial Stroop).

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12 Moreover, consistently with previous studies, responses were in general
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14 slower for gaze than arrow stimuli (Hietanen et al., 2006; Vlamings, Stauder, van
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16 Son, & Mottron, 2005). This suggests presumably that the coding of eye-gaze
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18 stimuli took more time than the coding of arrow stimuli. From our point of view,
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20 the slowing of reaction times observed for gaze stimuli may be due to their social
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22 significance and complexity that induces a greater exploration of it. Supporting
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24 this view, Vlamings and coworkers (2005) showed slower reaction times after
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26 eye-gaze than arrow stimuli only in typically developed individuals but not in
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28 individuals with autism, who are generally referred as impaired in social attention
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30 behavior (e.g., Leekam, Lopez, & Moore, 2000).
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35 Nevertheless, the most important result was the opposite congruency effect
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37 observed for eye-gaze and arrows within the same task. This dissociation is
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39 difficult to reconcile with the domain-general view of attentional process.
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41 Opposite congruency effects for gaze and arrows have been replicated in
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43 subsequent experiments in our laboratory (Roman-Caballero, Marotta, Martín-
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45 Arévalo, & Lupiáñez, 2017) and other studies have found that the reversed
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47 congruency effect is modulated by emotional expression of the face when the
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49 whole face instead of the eyes are used as targets (Jones, 2015; Torres-Marín,
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51 Carretero-Dios, Acosta y Lupiáñez, 2017), thus supporting the social nature of the
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53 effect.
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4 The reverse congruency effect found with eye-gaze stimuli seems
5 consistent with the idea that participants are especially fast when the target face
6 seems to look directly at them. Indeed, it is important to note that when a gaze
7 stimulus is presented on the left and looks to the right (incongruent trial), it is
8 looking to the centre, in the direction appropriate to make eye contact with the
9 participant. In contrast, if the target face is presented on the left and looks to the
10 left (congruent trial), it is looking away from the participant. This difference
11 between direct and averted gaze might underlie the reversion of the typical Stroop
12 effect observed with eye gaze.
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23 Indeed, a number of studies have found that human observers are faster to
24 detect a face (Senju, Kikuchi, Hasegawa, Tojo, Osanai, 2008) or eyes (Conty et al,
25 2006) when eye contact is maintained. Moreover, eye contact results in benefits in
26 processing for other face-related features such as the gender or the identity of the
27 face (Senju & Johnson, 2009). Thus, eye-contact could, therefore, explain the
28 “reversed” spatial Stroop effects observed in our and previous studies (Cañadas &
29 Lupiáñez, 2013), and would, therefore, be an essential social feature of the
30 attentional mechanisms triggered by gaze cues, able to dissociate between gaze
31 and arrow attention mechanisms.
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43 Another explanation for the reversed congruency effect might be related to
44 the “mentalizing” theory (Baron-Cohen, 1997), which refers to the human ability
45 to determine another individual's state of mind from eye gaze. In particular, eye
46 gaze may be used to perceive, explain, and anticipate the behaviour and/or the
47 intentions of others. Thus, rather than sharing mutual gazes in the incongruent
48 condition, participants and stimulus may be engaged in a joint encoding of
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4 information about self and others' attention; in other words, in incongruent trials,
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6 eyes presented on the left, but looking right might be interpreted as having an
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8 intent to move to the right so having this location an advantage regarding the
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10 participant's allocation of attentional resources (it is important to note that right-
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12 looking eyes required a right response). Consequently, maybe for this reason,
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14 discrimination of gaze direction is faster in the incongruent condition.
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17 Although more research is needed to clarify the nature of the reverse
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19 congruency observed with eye-gaze stimuli, both explanations seem coherent with
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21 the idea that another person's eye gaze indicates more than just a direction, it
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23 provides a window into their intentions and it can signal approach or avoidance
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25 (Hietanen et al., 2008). Arrows simply provide directional information and do not
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27 signal intent or the possibility of a social interaction. Probably, this is the reason
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29 why a classical spatial Stroop effect was observed when arrows were used as
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31 targets. The role of intent in gaze can also help explain the growing evidence of
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33 gaze-specific effects observed in the literature when a "qualitative" rather than a
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35 "quantitative" approach has been used to dissociate between gaze and arrow
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37 attentional mechanisms. In particular, these studies have focused on effects
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39 produced by gaze and arrow cues other than the usual facilitation effect such as
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41 object evaluation (e.g., Bayliss et al., 2006), object selection (Marotta et al.,
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43 2012), long-term memory (Dodd et al., 2012), working memory (Gregory and
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45 Jackson, 2016) and spatial interference as studied here.
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49 Our results constitute evidence against the domain-general view of
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51 attentional process and support the notion that social attention may be special, as
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53 it is hard to imagine how the same attentional mechanism could produce opposite
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4 influences on spatial interference. However, it is possible that gaze and arrow
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6 share some processes but not others. For example, in addition to the spatial
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8 interference effect, which might arguably be commonly produced by arrow and
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10 gaze stimuli, other processes such as eye-contact would be specific to gaze
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12 stimuli. Such processes should work in opposition to the spatial interference effect
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14 thus explaining the reversion of the observed spatial Stroop effect in the case of
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16 the eye-gaze stimuli. Therefore, on one hand, it could be argued that gaze and
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18 arrows, as directional cues, may share a domain-general attentional process
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20 responsible for the results usually found in both spatial cueing (e.g., Birmingham
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22 and Kingstone, 2009) and perspective taking literature (e.g., Santiesteban et al.,
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24 2014), showing similar effects for both cue types. On the other hand, other
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26 processes related to theory of mind and social interactions, would be invoked to
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28 explain why eye-gaze stimuli produce different effects from arrows when the
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30 nature rather than the magnitude of the attentional effects are considered.
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34 Future research using our paradigm with brain imaging techniques could
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36 be very useful to provide more direct evidence regarding the underlying processes
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38 contributing to the observed dissociation. One possibility is that the brain areas
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40 related to the domain-general attentional process would be involved with both
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42 arrows and gaze stimuli, while other brain circuits related to theory of mind and
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44 eye-contact such as the superior temporal sulcus would be especially involved
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46 with eye-gaze stimuli.
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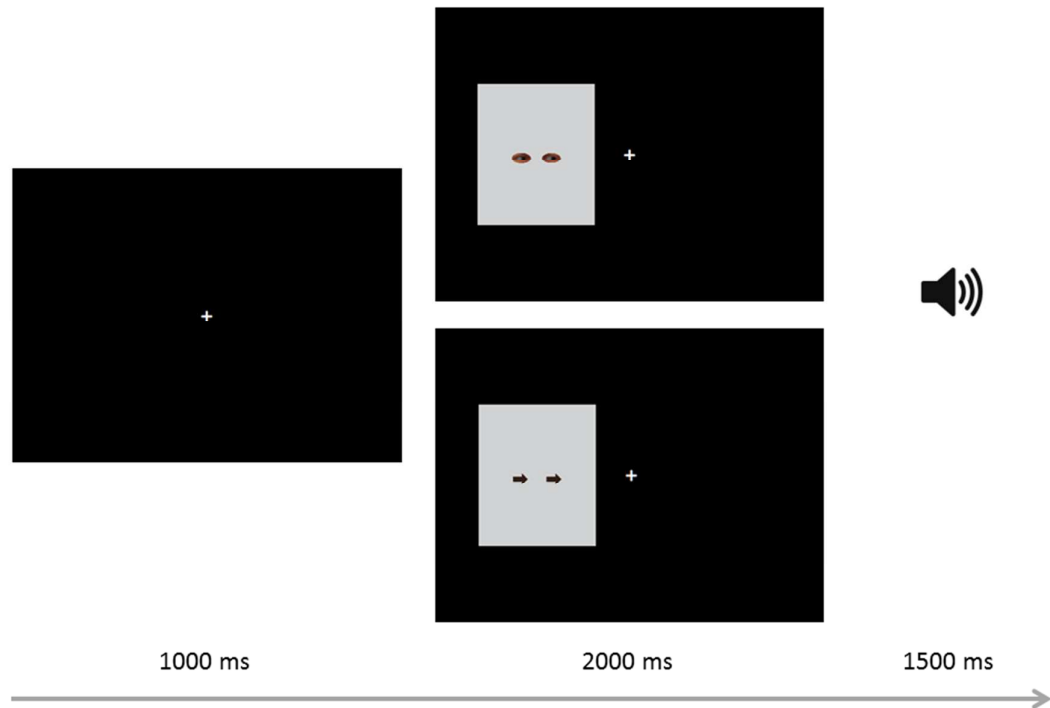


Figure 1. Schematic view of a trial sequence, from the left to the right for both the gaze target and the arrow target conditions. The example represents incongruent trials. The speaker icon represents the given auditory feedback.



Figure 2. Mean reaction time for each target type and trial type conditions. Error bars represent standard error of the mean, with between-participants variance removed with Cousineau's (2005) method..

Table 1. Mean Correct Response Times (RTs, in Milliseconds), Standard Deviations (SD) and Percentages of Incorrect Responses Errors (%IR) for Each Experimental Condition.

| TRIAL TYPE | GAZE | | | | ARROW | | | |
|-------------|--------|-------|------|------|--------|-------|------|------|
| | RT | SD | %IR | SD | RT | SD | %IR | SD |
| CONGRUENT | 596.65 | 70.35 | 3.71 | 5.85 | 496.99 | 64.53 | 2.11 | 2.4 |
| INCONGRUENT | 580.13 | 69.03 | 2.8 | 3 | 519 | 69.09 | 4.57 | 5.52 |