Journal of Experimental Psychology:
Human Perception and Performance

0096-1523/11/$12.00 DOI: 10.1037/a0023959

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Eye Gaze Versus Arrows as Spatial Cues: Two Qualitatively Different Modes of Attentional Selection

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This study aimed to evaluate the type of attentional selection (location- and/or object-based) triggered by two different types of central noninformative cues: eye gaze and arrows. Two rectangular objects were presented in the visual field, and subjects' attention was directed to the end of a rectangle via the observation of noninformative directional arrows or eye gaze. Similar experiments with peripheral cues have shown an object-based effect: faster target identification when the target is presented on the cued object as compared to the uncued object, even when the distance between target and cue was the same. The three reported experiments aimed to compare the location- and object-based attentional orienting observed with arrows and eye gaze, in order to dissociate the orienting mechanisms underlying the two types of orienting cues. Results showed similar cueing effects on the cued versus oppositely cued locations for the two cue types, replicating several studies with nonpredictive gaze and arrow cues. However, a pure object-based effect occurred only when an arrow cue was presented, whereas a pure location-based effect was only found for eye-gaze cues. It is suggested that attention is nonspecifically directed to nearby objects when a noninformative arrow is used as cue, whereas it is selectively directed to a specific cued location when noninformative eye gaze is used. This may be mediated by theory of mind mechanisms.

Keywords: gaze cueing, arrow cueing, object-based attention, location-based attention

The ability to accurately encode other people's direction of attention is crucial in social communication. By using this information, we are able to access information related to somebody else's intentions and mental states (Baron-Cohen, 1995a, b). For instance, we can infer what another person might be interested in (Lee, Eskritt, Symons, & Muir, 1998) and, consequently, what he or she might want to do next (Castiello, 2003). Furthermore, others' gaze direction indicates their direction of attention and focus of interest in the surrounding space. Hence, when we see someone looking in a particular direction, it is beneficial to shift our attention to the same location in space (Moore & Dunham, 1995). This "joint attention" mechanism is clearly of great benefit to an individual and has been posited as vital in the development of social communicative skills; for example, it can support language acquisition, cultural learning and theory-of-mind development in infants (Baron-Cohen, 1995b; Bruner, 1983; Tomasello, 1995; Tomasello, Kruger, & Ratner, 1993).

Over the last two decades, this behavior has been the focus of interest not only for researchers studying social cognition and human development, but also for those exploring the mechanisms of visual attention (for a review, see Frischen, Bayliss, & Tipper, 2007). Several recent studies have proven that gaze direction—used as a directional cue—reflexively triggers attentional shift (e.g., Driver et al., 1999; Friesen & Kingstone, 1998; Hietanen, 1999). These studies used a spatial cueing paradigm, first introduced by Posner (1980) and later revisited by Friesen and Kingstone (1998), in which a face is presented at fixation unpredictably gazing either left or right, as a cue to orient attention. After this, a target is presented either in the gazed location or in the opposite location. Participants are typically quicker at detecting or identifying the target when it appears at the gazed location, as compared to the opposite ungazed location (gaze cueing effect). This effect occurs even when the gaze direction is not predictive of the subsequent target location and observers are instructed to ignore it (see, e.g., Friesen & Kingstone, 1998), and even when they are told to expect targets at the opposite location (see e.g., Driver et al., 1999).

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This study was supported by research grants from the Spanish Ministry of Science and Education, PSI-2008-03595PSIC, and EUI2009-04082 in the frame of ERA-NET NEURON. Funding was also provided by a fellowship, CUN6-2010, from the University of Sapienza.

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On the basis of these findings, some researchers have proposed that automatic orienting to eye gaze represents a unique attentional process that is qualitatively distinct from attentional orienting triggered by biologically irrelevant stimuli (e.g., Langton & Bruce, 1999; Driver et al., 1999; Friesen & Kingstone, 1998). However, contrary to this position, a considerable body of research has provided behavioral evidence for similar results when arrows are used as cues instead of eye gaze (Hommel, Pratt, Colzato & Godijn, 2001; Kuhn & Benson, 2007; Tipples, 2002, 2008). For example, participants are quicker to respond to targets appearing congruently to the arrow direction (arrow cueing effect) even when it is counterpredictive and it is beneficial for participants to redirect attention away from the arrow-pointed position (Tipples, 2008). Furthermore, it has also been observed that arrow cues produce attentional effects even when the target appears very quickly after the cue onset (e.g., Gibson & Bryant, 2005), as found with eye-gaze cues (e.g., Hietanen & Leppanen, 2003). Other studies have directly compared the two effects. Thus, for example, Brignani, Guzzon, Marzi, and Miniussi (2009) found similar behavioral effects and electrophysiological correlates of attentional orienting after eye-gaze and arrow cues.

However, as underlined by Gibson and Kingstone (2006), studies have usually explored gaze and arrow cues on a dimension in which they share a great deal of similarity, namely their ability to communicate directional information. Nevertheless, the possibility of different attentional selection mechanisms has been ignored. In other words, since both types of cue provide directional information we have a lot of experience with (either due to their biological or social meaning, or to extensive practice), a fast and strong cueing effect has been observed with both arrows and gaze. However, there might be differences in how (instead of whether or not, or how much) attention is oriented in the direction primed by the cue depending on the type of cue.

A study by Egly, Driver, and Rafal (1994) was decisive in establishing that attentional selection occurs not only for spatial locations but also for objects. They presented a display with two rectangles, one of which was cued at one end or another by a peripheral cue; targets followed in one of three critical conditions: at the *cued* location, at the uncued location of the same rectangle (same-object target) or at the closest uncued location of the other rectangle (different-object target). By separating the objects by a distance equal to their length, the spatial distance between the cued location and both uncued locations was objectively equal (see Figure 2). Egly et al. found that participants were faster detecting validly cued targets than invalidly cued targets (including same-object targets). This suggested that distance from the cued location was affecting performance—a space-based effect. More important, by comparing the two uncued locations, they found that RTs were faster for same-object targets than for different-object targets. This showed that the encompassing rectangle was also influencing the allocation of attention—an object-based effect. These effects have been replicated in many subsequent studies using various adaptations of the paradigm (e.g., Abrams & Law, 2000; Goldsmith & Yeary, 2003; Macquistan, 1997). However, to our knowledge, it has not been studied yet whether gaze and arrow cues trigger object-based effects and whether location- and object-based selections are able to identify qualitative differences between biologically relevant (i.e., gaze) and irrelevant stimuli (i.e., arrows).

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The qualitative approach taken in the current paper has been successfully used in previous studies to dissociate endogenous from exogenous attention (e.g., Funes, Lupiáñez & Milliken, 2007; Macquistan, 1997). More specifically, in order to test whether gaze cues have a social special status in orienting attention, this study included a comparison between the type of attentional selection triggered by directional arrows and eye gaze. A variant of the double-rectangle task (Egly et al., 1994), described earlier (see Figure 2), was used for this purpose. According to a "theory of mind" interpretation of joint attention (Baron-Cohen, Wheelwright, & Jolliffe, 1997; Calder et al., 2002), the encoding of gaze direction enables us to access others' internal attentional state, which allows us to make predictions about their future actions (Baron-Cohen et al., 1997; Calder et al., 2002). Therefore, establishing a correct representation of others' attentional state should orient our attention to the location in space or the part of the object that gaze is directed to (Emery, 2000). In light of this, it was expected that eye gaze direction would orient attention specifically to the location or part of the object looked at rather than spreading attention through the whole placeholder object. After all, we should not be interested in one corner of a table, for example, when we see somebody looking at the opposite corner, given that we are very accurate in determining gaze direction (Bock, Dicke, & Their, 2008). Such social mechanisms are not predicted to be active, however, when the spatial cue is an arrow. This is because an arrow has a directional property, just like gaze, but no biological significance. This type of cue should therefore induce a more typical stimulus-driven object-based cueing effect, spreading attention through the entire placeholder object.

Experiment 1

The primary purpose of Experiment 1 was to test for qualitative differences between arrow and gaze cueing; more specifically, the aim was to test whether object-based effects are present under arrow cueing but absent under eye-gaze cueing. Moreover, in order to replicate previous literature and establish a baseline in which arrow and gaze cues produce similar cueing effects we tested a general benefit for the cued direction. A variant of the object-cueing paradigm was used in which two rectangles were presented, with targets appearing at one end (see Figure 2). Rectangles were tilted so that one end of each rectangle was either to the left or to the right of the fixation point, and the other ends were either above or below fixation. Arrow and eye-gaze cues were presented at fixation in separate blocks of trials, either directing attention to the left or to the right. Targets appeared to the left or to the right, in the same direction (and object) indicated by the cue (same-location/same-object trials) or in the opposite object and direction to which the cue was directed (opposite-location/opposite-object trials); above or below fixation, in the same object (same-object trials) to which attention was directed (but always in an orthogonal direction) or in the other object (different-object trials). In order to test the typical directional effect triggered by spatial cues (*general cueing effect*[1]) we compared same-location/same-object trials to opposite-location/opposite-object trials. Moreover, to explore the Fn1

[1] Note that, as in most studies, these conditions measured Location- plus Object-based cueing.

critical object-based effect (*object-based cueing effect*) we compared same-object trials to different-object trials.

Method

Participants

Twenty-four university students (17 females and 7 males; mean age 24 ± 3 years) gave their informed consent before participating as volunteers in the study. The study was approved by the local ethics committee. All participants had normal or corrected-to-normal vision, and were unaware of the purpose of the experiment.

Apparatus

Stimuli were presented on a 21-inch color VGA monitor. An IBM-compatible PC running E-Prime software controlled the presentation of the stimuli, timing operations, and data collection. Responses were gathered with a standard keyboard.

Stimuli

F1 As shown in Figure 1, stimuli of the fixation display were two rectangular objects subtending 10.5° × 3° of visual angle and presented in two possible orientations (+45° or −45° tilted from the vertical meridian). In the gaze-cueing paradigm, the fixation was a central schematic face (3° × 2.5°) with the pupils straight; the spatial cue was the same central schematic face with the pupils directed either to the left or to the right. In the arrow cueing paradigm, a horizontal line (0.5° × 2°) was used as fixation. An arrow-head directed either to the left or to the right was used as the arrow-cue. Target stimuli were the letters “X” or “O” (0.9° × 0.9°). All stimuli were black on a white background.

Procedure

Participants were seated at a distance of about 56 cm from a computer monitor, in a dimly lit, sound-attenuated room; their heads were held steady with a chin/head rest. A trial sequence of the procedure is shown in Figure 1.

Each trial began with a display consisting of a central fixation stimulus and two rectangular objects (one at each side of the screen) presented randomly in two possible orientations (+45° or −45° from the vertical meridian). The fixation stimuli differed depending on the cue types. In gaze cueing, the fixation stimulus was a central schematic face with the pupils centered vertically in the eyes. In arrow cueing, the fixation stimulus was a horizontal line centered on the screen. This display was presented for 700 ms. The cue’s appearance resulted from the “movement” of the eyes randomly to the left or to the right, or the appearance of arrow-heads on one of the sides. These cues were not predictive of target location. The target appeared after 150, 300, or 600 ms, at one of

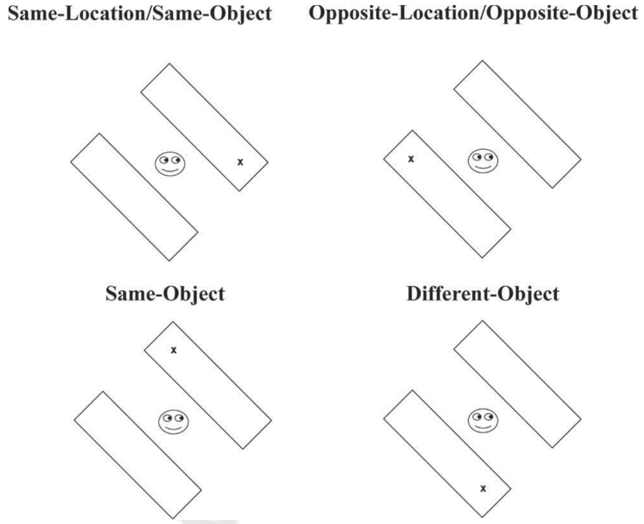

Figure 2. Illustration of the four cue-target (CT) relation conditions. The display orientation depicted here is −45° from vertical.

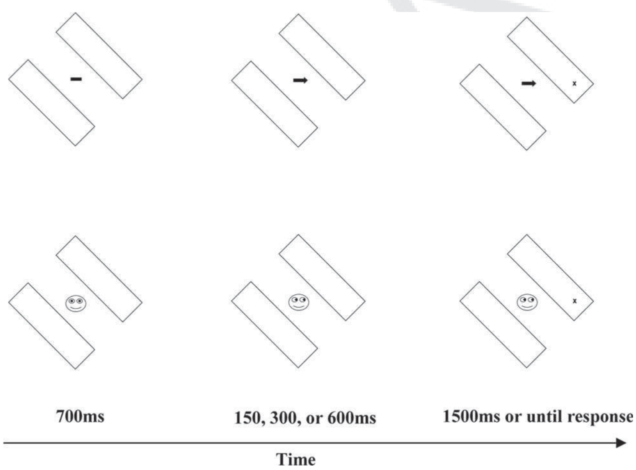

Figure 1. Schematic view of a trial sequence from right to left for both the gaze cue and the arrow cue conditions. The example represents a same-location/same-object trial.

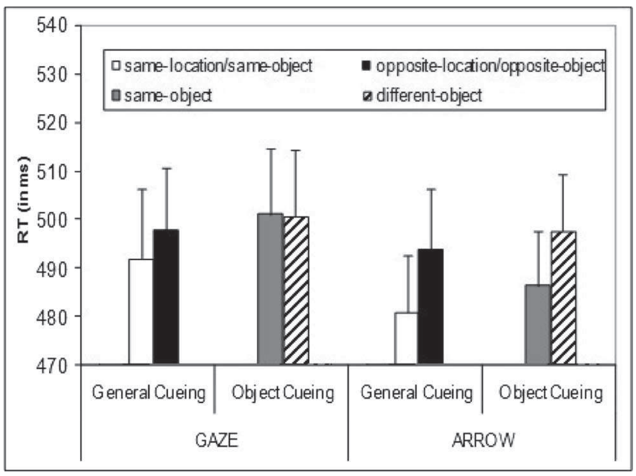

Figure 3. Reaction times (RTs) results from Experiment 1. Mean reaction times presented for each cue type condition (gaze and arrow) as a function of cue-target relation (CT). Error bars represent the standard error of the mean for each condition.

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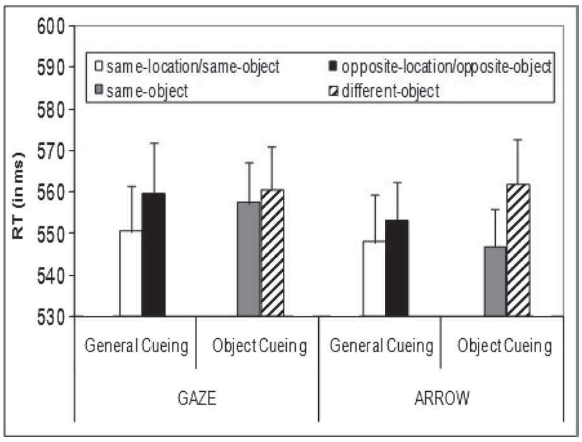

Figure 4. Reaction times (RTs) results from Experiment 2. Mean reaction times presented for each cue type condition (gaze and arrow) as a function of cue-target relation (CT). Error bars represent the standard error of the mean for each condition.

the four possible locations (6° from the center of the screen). When presented on the horizontal axis (general cueing), targets appeared in the same direction and the same object to which the cue was directed (same-location/same-object trials); or in the opposite object and direction (opposite-location/opposite-object trials). When presented on the vertical axis (object-based cueing), targets appeared in the same object (same-object trials) indicated by the cue or in a different object (different-object trials), despite their equivalent distance from the cued location. The target display remained until a response was given or until 1500 ms had elapsed. A blank screen was then presented for 700 ms after each trial. Participants completed a practice block of 25 trials, followed by two experimental blocks of 312 trials each (one for each cue type). Twelve catch trials, in which no target was presented, occurred randomly in each block. Cue direction, target location, object orientation, and cue–target stimulus onset asynchrony (SOA) were randomly selected within each block of trials.

Participants were instructed to respond to the presentation of the target by pressing either the "C" key (with the left hand) or the "M" key (with the right hand) on the computer keyboard depending on the target letter that was presented. Half of participants pressed "C" for the letter "X" and "M" for the letter "O", whereas the other half received the reversed mapping. They were informed that the direction of the central cue did not predict target location, and that they should ignore it, while maintaining central fixation throughout each trial.

Design

Separate three-factor repeated measure designs were used to analyze "general cueing" and "object-based cueing," effects respectively for targets appearing at the left and right locations, and for targets appearing at the top and bottom locations.

Cue-Target (CT) relation consisted of four trial types: same-location/same-object trials and opposite-location/opposite-object trials were entered in the analysis of the general cueing effect; in contrast, same-object trials and different-object trials were entered in the analysis of object-based cueing effect. Type of Cue had two levels: eye gaze and arrow. SOA had three levels: 150, 300, and 600 ms.

Planned comparisons were used for the analysis of interactions. The order of blocks with each cue type (gaze/arrow) was counterbalanced across participants.

Results

General Cueing

Mean response times and error rates are shown in Table 1. RTs T1 faster than 100 ms or slower than 1200 ms (0.7% of the trials) and trials with an incorrect response (7%) were excluded from the RT analysis. A Type of Cue (gaze vs. arrow) × SOA (150, 300, and 600 ms) × CT relation (same-location/same-object trials vs. opposite-location/opposite-object trials) repeated measures analysis of variance (ANOVA) was performed on the data from trials in which the target was presented at the left and right locations. The analysis revealed a main effect of CT relation ($F_{1,23} = 8.78$; $p = .007$), showing that RTs were faster on same-location/same-object ($M = 486$ ms) than on opposite-location/opposite-object trials ($M = 496$ ms). In addition, mean RTs decreased with the SOA ($F_{2,46} = 5.04$; $p = .011$). No other effect was significant (Fs < 2). It is important that no interaction involving the Type of Cue variable approached significance (all ps $> .12$).

The analyses of error rate showed a significant effect of CT relation ($F_{1,23} = 220.47$; $p < .0001$), indicating that participants made more errors on invalid (11%) than on valid trials (3%). Type of Cue was significant ($F_{1,23} = 161.56$; $p < .0001$) and revealed more errors with arrow (10%), then with gaze cues (4%). The only other significant effect was the Type of Cue × CT relation ($F_{1,23} = 92.14$; $p < .0001$) interaction, showing a larger cueing effect for arrow cues, although the effect was significant for both arrow and eye-gaze cues ($F_{1,23} = 373.91$; $p < .0001$ and $F_{1,23} = 5.34$; $p = .03$, respectively). No other effect was significant ($F < 2$).

Table 1
Mean Reaction Times and Percentage of Errors (in Parentheses) as a Function of SOA, CT Relation, and Type of Cue in Experiment 1

	Gaze cue				Arrow cue			
SOA	SamLoc	OppLoc	SamObj	DifObj	SamLoc	OppLoc	SamObj	DifObj
150 ms	496.91 (2.2%)	501.41 (4.5%)	508.46 (6.6%)	502.63 (3%)	489.53 (4.3%)	506.96 (16.5%)	501.09 (5.1%)	499.09 (4.6%)
300 ms	487.11 (3.3%)	499.19 (5.2%)	499.80 (4.4%)	497.70 (3.5%)	482.84 (3.4%)	487.90 (17.1%)	485.51 (3.2%)	501.40 (4.7%)
600 ms	491.70 (3.7%)	496.91 (5%)	494.70 (2.6%)	501.85 (4.5%)	470.43 (3.8%)	486.31 (15.5%)	472.69 (3.5%)	492.73 (6.5%)

Object-Based Cueing

T2 Mean response times and error rates are shown in Table 2. RTs faster than 100 ms or slower than 1200 ms (0.5% of the trials) and incorrect response trials (4.5%) were excluded from the RT analysis. A Type of Cue (gaze vs. arrow) × SOA (150, 300 and 600 ms) × CT relation (same-object trials vs. different-object trials) repeated measures ANOVA revealed that RTs decreased with SOA ($F_{2,46}$ = 5.93; $p < .005$). The main effect of CT relation was marginally significant ($F_{1,23}$ = 3,72; $p = .06$). It is important that the Type of Cue × CT relation interaction was significant ($F_{1,23}$ = 7.84; $p < .01$). RTs were faster on same-object trials than on different-object trials, when arrows were used as cues ($F_{1,23}$ = 17.64; $p < .001$). Yet, no differences were found between same-object and different-object trials when eye gaze was used ($F < 1$). The only other significant effect was the SOA × CT relation interaction ($F_{2,46}$ = 3.31; $p < .05$), revealing a significant facilitation effect for the longest SOA of 600 ms ($F_{1,23}$ = 10.88; $p < .01$), but not for the two short SOAs of 150 and 300 ms. No other effect was significant ($F < 1$).

The analyses of error rates also showed a significant Type of Cue × CT interaction ($F_{1,23}$ = 9,04; $p < .01$); participants made more errors in different-object (5.3%) than in same-object trials (3.9%), when arrows were used as cues ($F_{1,23}$ = 3.56; $p = .05$). No differences were found between same-object (4.5%) and different-object trials (3.7%) when eye gaze was used ($F_{1,23}$ = 3.4; $p = .08$). Furthermore, the SOA × CT interaction ($F_{2,46}$ = 6.70; $p = .002$), revealed more errors in different-object than in same-object trials for the longest SOA −600 ms ($F_{1,23}$ = 8.18; $p < .01$); no differences were found between same-object and different-object trials for the 300-ms SOA, and more errors were observed in same-object than in different-object trials for the shortest SOA of 150 ms ($F_{1,23}$ = 5.10; $p < .05$). No other effect was significant ($F < 2$).

Discussion

Results of this experiment suggest that attention spreads to the entire object when a noninformative arrow is used as cue; on the contrary, it appears to be selectively directed to a cued location, that is, the specific location looked at, when noninformative eye gaze is used. Consistent general cueing effects were found with both types of cues, thus replicating previous studies with nonpredictive gaze cues (e.g., Driver et al., 1999; Friesen & Kingstone, 1998) or arrow cues (Hommel et., 2001; Tipples, 2002). In sharp contrast, object-based cueing effects clearly depended on the type of cue that was used to direct attention. Using an arrow, target discrimination was faster for the cued object than the uncued object. This object-effect was not found for noninformative eye-gaze cues. This finding implies that arrow cues, as exogenous cues, can trigger shifts of attention that spread to the entire object in the visual field; eye-gaze cues, however, orient our attention specifically to the cued location, not to the entire object. Of course, the present results should not lead to the conclusion that attention can never be directed to objects via the observation of noninformative eye gaze. Instead, they suggest that attentional selection is not obligatorily object-based when directed in response to gaze cues. When the entire object is the current focus of interest of gaze direction, the attentional effect could be modulated by that object; for instance, Bayliss and Tipples (2005) found that, in this case, the magnitude of orienting to the direction of both gaze and arrow cues can be modulated by the social relevance of the object in which the target appears.

The next experiments replicate the main finding of the present experiment. Their interpretation is elaborated in the General Discussion.

Experiment 2

In the previous experiment, the type of cue (gaze or arrow) was manipulated between experimental blocks. Thus, participants might have adopted different strategies for eye-gaze and arrow cue blocks. Consequently, the different findings observed in the two experimental blocks might not be related to different attentional mechanisms directly elicited by each cue type; instead, they might be determined by the different attentional strategies adopted by participants (for a review of the role of participants' task set in modulating cueing effects, see Ruz & Lupiáñez, 2002). In order to control for this possibility and to replicate the main findings obtained, a second experiment was conducted. It was essentially a replication of Experiment 1, except that the type of cue varied randomly across trials.

Method

Stimuli and procedure were nearly identical to those used in Experiment 1, except for the order of spatial cues: trials with eye gaze and arrows were randomly interspersed in each of the two blocks of trials. In this case, the orientation of the rectangles was blocked, so that in one block of trials the two placeholder rectangles were tilted to the left and in the other block (in counterbalanced order) they were tilted to the right. This strategy was used to maintain the structure of the experiment while randomizing the type of cue in trial blocks. A different group of 24 students (21 females and 3 males; mean age 24 ± 3 years)

Table 2
Mean Reaction Times and Percentage of Errors (in Parentheses) as a Function of SOA, CT Relation, and Type of Cue in Experiment 2

	Gaze cue				Arrow cue			
SOA	SamLoc	OppLoc	SamObj	DifObj	SamLoc	OppLoc	SamObj	DifObj
150 ms	550.26 (4.0%)	572.85 (3.9%)	558.83 (3.7%)	564.23 (3.9%)	564.74 (5.1%)	565.42 (5.2%)	557.74 (3.8%)	569.71 (4.6%)
300 ms	557.13 (3.1%)	550.90 (3.0%)	566.74 (3.7%)	565.09 (3.6%)	541.76 (3.7%)	549.34 (4.2%)	549.68 (4.5%)	562.26 (3.1%)
600 ms	543.62 (3.4%)	554.81 (3.8%)	546.09 (4.6%)	553.04 (3.7%)	537.29 (3.1%)	547.08 (3.6%)	532.76 (3.1%)	554.11 (2.8%)

participated in this experiment, with the same characteristics as those of Experiment 1.

Results

General Cueing

Mean reaction times and error rates are shown in Table 3. Trials with RTs faster than 100 ms or slower than 1200 ms (0.7% of the trials), as well as those with incorrect responses (3.8% of the trials), were excluded from the RT analysis. The ANOVA revealed faster RTs on same-location/same-object trials (M = 549 ms) than on opposite-location/opposite-object trials (M = 559 ms; $F_{1,23}$ = 9.85; p = .0046). In addition, RTs decreased with SOA ($F_{2,46}$ = 8.05; $p < .001$). The Type of Cue × SOA interaction was significant ($F_{2,46}$ = 3.61; p = .035), showing a larger effect of SOA in the arrow than in the gaze condition. No other effect was significant. Analyses of error rates showed no significant effects.

Object-Based Cueing

Mean response times and error rates are shown in Table 4. Trials with RTs faster than 100 ms or slower than 1200 ms (0.5% of the trials) and those with incorrect responses (3.7% of the trials) were excluded from the RT analyses. The ANOVA revealed that RTs on same-object trials (M = 552 ms) were significantly faster than RTs on different-object trials (M = 561 ms; $F_{1,23}$ = 14.06; $p < .001$), showing an object-based orienting effect. RTs also decreased with SOA ($F_{2,46}$ = 12.44; $p < .0001$). In addition, the Type of Cue × CT relation interaction was significant ($F_{1,23}$ = 4.11; $p < .05$): RTs on same-object trials were faster than on different-object trials when arrows were used as cues ($F_{1,23}$ = 16.51; p = .0005); yet, no differences were found between same-object and different-object trials when eye gaze was used ($F < 1$). No other effect was significant. Analyses of error rates showed no significant effects.

Combined Analysis of Experiment 1 and 2

In order to check for differences between the two experiments, results from the Object-based cueing condition of Experiments 1 and 2 were analyzed in a 2 (Experimental Design: Blocked vs. Mixed) × 2 (Type of Cue: gaze vs. arrow) × 3 (SOA: 150, 300, and 600 ms) × 2 (CT relation: same-object vs. different-object) mixed-design ANOVA. The analysis showed a significant CT relation × Type of Cue interaction ($F_{1,46}$ = 10.75; $p < .01$), which was independent of the Experimental Design (F < 1). The main effect of Experimental Design was significant ($F_{1,46}$ = 17.20; $p <$ .0001) and revealed faster RTs (496 ms) in Experiment 1 than in Experiment 2 (557 ms). However, no interaction with Experimental Design was significant (F < 2). Again, the object-based validity effect was significant with arrow cues ($F_{1,46}$ = 33.04; $p < .0001$) but not with gaze cues (F < 1). Furthermore, the same mixed-design ANOVA (Experimental Design: Blocked vs. Mixed; Type of Cue: gaze vs. Arrow; SOA: 150, 300, and 600ms; CT relation: same-location/same-object vs. opposite-location/opposite-object) conducted on RTs from Experiment 1 and 2 showed a significant general cueing effect ($F_{1,46}$ = 18.61; $p < .0001$), which was independent of Type of Cue (F < 1) and Experimental Design (F < 1).

Discussion

Experiment 2 replicated all the important findings of Experiment 1. Consistent general cueing effects were found with both gaze and arrow cues. In contrast the object-based cueing-effect was found only with arrow cues, but not with gaze cues. Since the type of cue was manipulated randomly within blocks of trials in this experiment, this finding demonstrates that the observed results are due to actual differences in the selection mechanisms elicited by the two types of cue rather than to different between-block strategies. As shown in the combined analysis, the same results were observed in both experiments regarding both general and object-based attentional cueing. Therefore, it can be concluded that the dissociation observed between gaze and arrow cueing cannot be explained by the use of different attentional orienting strategies in different blocks of trials.

The object-based effect of the present study was purely object based, as previously measured in the attention literature (Egly et al., 1994). However, the general cueing effects of this study were in fact a mixture of location- and object-based effects. The following experiment was performed to test for specific location-based orienting effects.

Experiment 3

The primary purpose of the previous experiments was to test whether object-based effects are present under arrow cueing but absent under eye-gaze cueing. Moreover, a general cueing effect (targets appearing to the left or to the right, in the same or in the opposite direction indicated by the cue) was only used to establish a baseline in which arrows and gaze cues produce similar cueing effects, as shown in previous literature. However, eye-gaze and arrow cues directed attention only to the left or to the right. Consequently, no specific location-based effect (RT difference for same-location/same-object trials vs. same-object trials) was tested because same-location/same-object trials were always paired with a horizontal target, whereas same-object trials were always paired with a vertical target. As such, it is unclear whether a specific location-based effect is similarly triggered by gaze and arrow cues

Table 3
Mean Reaction Times and Percentage of Errors (in Parentheses) as a Function of CT Relation and Type of Cue in Experiment 3

Gaze cue				Arrow cue			
SamLoc	OppLoc	SamObj	DifObj	SamLoc	OppLoc	SamObj	DifObj
538.42 (4.0%)	548.02 (3.9%)	546.76 (4.0%)	551.59 (4.0%)	537.24 (3.5%)	559.98 (3.7%)	536.96 (4.0%)	554.83 (3.6%)

or whether this effect (like the object-based effect) is able to identify qualitative differences between biologically relevant and irrelevant cues. Therefore, a third experiment was conducted to explore this. Experiment 3 included an additional manipulation of the cue direction (up and down). Thus, in this new experiment any of the four locations could be indicated by either of the two types of cue (arrow and gaze). Furthermore, the two cue types and rectangle orientations were randomly intermixed within blocks of trials. To shorten the length of the experiment, only the medium 300 ms SOA was used.

We expected the general cueing effect to be present for the two cue types, as in previous experiments. However, regarding the object-based and specific location-based effects we expected to find a double dissociation with cue type: whereas the specific location-based would be observed only for gaze cues, the object-based effect would be only observed for arrow cues.

Method

The stimuli used in this experiment were similar to the ones used in Experiments 1 and 2, but some changes were made to the procedure. First, an additional manipulation of the cue direction was introduced: the spatial cue (arrows or eye gaze) was presented centrally indicating one of four possible directions (upward, downward, left, or right). Second, cue direction, cue type, object orientation and target location were all randomly selected within each of two blocks of trials. Third, to simplify the design and reduce the length of the experiment, only one level of SOA was used: 300 ms. Participants completed a practice block of 15 trials, followed by 288 experimental trials (144 trials for each cue type).

A different group of 30 students (23 females and 7 males; mean age 21 ± 4 years) participated in this experiment, with the same characteristics of those of the previous Experiments.

Design

The experiment used a within-subjects design with the following factors: cue direction, type of cue, and cue-target (CT) relation. Cue Direction had two levels: vertical axis (cue direction was up or down) and horizontal axis (cue direction was left or right). Type of Cue had two levels: eye gaze and arrow. CT relation had four levels: same-location/same-object, opposite-location/opposite-object, same-object, different-object. The comparison between same-location/same-object and same-object trials made it possible to measure a specific location-based effect. The comparison between same-object and different-object trials was used to study the object-based effect.

Results

Trials with RTs faster than 100 ms or slower than 1200 ms (0.6% of the trials), as well as those with incorrect responses (5% of the trials), were excluded from the RT analysis. Mean response times and error rates for each CT condition with the arrow and eye-gaze cues are shown in Table 3.

The effect of Cue Direction on performance was examined first. The main effect was not significant ($F < 1$) and no interactions were observed with Cue Direction ($p > .12$). The remaining analyses were therefore collapsed across this factor.

RTs differed as a function of CT relation ($F_{3,87} = 9.58$; $p < .0001$). It is important that the CT relation was modulated by the Type of Cue ($F_{3,87} = 4.79$; $p = .004$; Figure 5). This interaction was analyzed according to our specific predictions that a) a general cueing effect would be observed as in the previous experiments, and independently of cue type; b) the object-based effect would be observed only for arrow cues; and c) the specific location-based effect would be only observed for arrow cues. The three predictions were confirmed: Replicating the main result of the previous experiments, RTs on same-location/same-object trials were faster than on opposite-location/opposite-object trials (general cueing effect), $F1, 29 = 11.76$; $p < .002$, and independently of Cue Type, $F1, 29 = 2.21$; $p = .147$. RTs on same-object trials were significantly faster than RTs on different-object trials (object-based effect), but only when arrows were used as cues, $F_{1,29} = 14.42$; $p = .0007$ ($F < 1$, with eye-gaze cues). In contrast, RTs on same-location/same-object trials were significantly faster than RTs on same-object trials (specific location-based effect), but now only when eye gaze was used as cue, $F_{1,29} = 4.87$; $p = .035$ ($F < 1$, with arrow cues). The main effect of Type of Cue was not significant ($F < 1$). F5

Analyses of error rate showed no significant effects.

Discussion

Consistent with the previous findings, an object-based cueing-effect was found only for arrow cues but not for gaze cues in this experiment. In addition, a specific location-based effect was only found for eye-gaze cues, but not for arrow cues. The present results are difficult to reconcile with the view that similar attentional orienting mechanisms are involved with gaze and arrow cues. Instead, such findings suggest that qualitatively distinct modes of attentional selection are triggered by the two types of cues. Indeed, the results reported here constitute a *double dissociation* within the same task context. The specific location-based effect observed

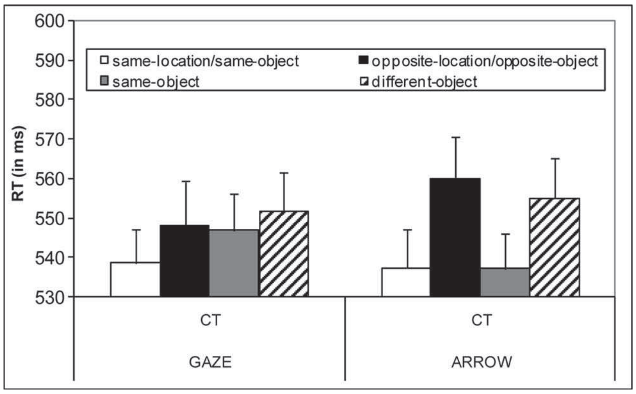

Figure 5. Reaction times (RTs) results from Experiment 3. Mean reaction times presented for each cue type condition (gaze and arrow) as a function of cue-target relation (CT). Error bars represent the standard error of the mean for each condition. Note that a general cueing effect (opposite-location/opposite-object—same-location/same-object) is observed for both types of cues, the object-based cueing effect (different—same object) was only observed for arrow-cues, and the specific location-based cueing effect (same-object—same-location/same-object) was only observed for gaze-cues.

with eye-gaze cues seems consistent with the idea that gaze reflects "social" processing and that an intention is attributed to the gaze to look at a specific location. Gaze direction gives us a good idea of the focus of interest of another individual, and we are quite good at inferring gaze direction (e.g., Bock et al., 2008). Hence, we jointly orient our attention specifically to the inferred location within the object of interest, not to the entire object. In contrast, the object-based effect of arrow cues may be triggered by a more unspecified directional code that automatically orients attention trough the entire placeholder object. Consistent with this hypothesis, object-based effects are generally observed following other nonsocial cues (i.e., peripheral cues; Egly et al., 1994; Macquistan, 1997).

General Discussion

In a series of three experiments, the present study explored the critical role played by the type of attentional selection in dissociating attentional orienting under eye-gaze and arrow cueing. One part of the data replicates the results usually found in the literature (e.g., Stevens, West, Al-Aidroos, Weger & Pratt, 2008; Tipples, 2008), showing similar attentional effects for both cue types when targets appeared in the specifically cued direction (vs. the opposite location). In contrast, the remaining data revealed a qualitative dissociation between the type of attentional selection triggered by arrow and eye-gaze cues: an object-based effect (RT difference in same-object trials vs. different-object trials) was only observed when an arrow was used as cue; in contrast, a specific location-based effect (RT difference for same-location/same-object trials vs. same-object trials) was only observed following an eye-gaze cue. These findings challenge the suggestion that similar attentional orienting mechanisms are involved with gaze and arrow cues (Ristic et al., 2002; Tipples, 2002; Tipples, 2008, Experiment 3). Instead, they support the view that automatic orienting in response to gaze cues represent a unique attentional process that is qualitatively distinct from attentional orienting triggered by biologically irrelevant stimuli (e.g., Langton & Bruce, 1999; Driver et al., 1999; Friesen & Kingstone, 1998).

As a matter of fact, arrow cues allow attentional shifts that spread to the entire object in the visual field, whereas gaze effects only occur in the specific direction indicated by the cue. The origin of this difference may lie in the dissimilar encoding and function of the two cues. In particular, it was speculated that biologically and socially relevant gaze cues may encourage more specific attentional orienting, compared to arrow cues, since a specific intention may be automatically attributed to gaze and not to arrows. The attention system has developed a tendency to use social gaze direction as a powerful cue. We are very good at perceiving where another individual is looking (e.g., Bock et al., 2008; Cline, 1967; Symons, Lee, Cedrone, & Nishimura, 2004); by using this ability we can infer the internal mental states of other humans, which allows us to make predictions about their future actions (Emery, 2000). Therefore, if an intention is attributed to the gaze (through theory of mind mechanisms) to look at a specific location, it is conceivable that we will jointly orient our attention specifically to the inferred location or part of scene, not to the entire object. This hypothesis seems consistent with Vuilleumier's observation (2002, Experiment 4) that gaze cues do not merely induce general hemispatial attentional orienting, but rather specific location orienting. Such social mechanisms are not predicted to be active, however, when the spatial cue is an arrow. Orienting after nonpredictive arrows may rather reflect a more default stimulus-driven system that nonspecifically orients attention trough the entire object. In fact, object-based effects are generally observed following other types of nonsocial cues (i.e., exogenous peripheral cues; Macquistan, 1997).

It is unlikely that a different pattern of results would have been obtained using real rather than schematic faces. There is evidence suggesting that schematic faces and photorealistic faces are processed similarly. For example, Doherty et al. (Doherty & Anderson, 1999; Doherty, Anderson, & Howieson, 2009) found that preschool children (3 and 4 years old) can similarly ascribe mental states on the basis of both schematic faces and pictures of real faces. Moreover, Hietanen and Leppanen (2003) compared the cueing effects for schematic and real directional eye gaze and found no difference between both.

It seems more likely that the origin of the present results resides in the dissimilar way in which eye-gaze and arrow cues are processed. This view is supported by a growing body of neurological studies suggesting that attentional orienting in response to eye-gaze cues is qualitatively different from the type of orienting resulting from arrow cues. For example, studying a split-brain patient, Kingstone, Friesen, and Gazzaniga (2000) showed that reflexive orienting to eye gaze was lateralized to the right hemisphere, whereas no such effect was found using arrows (Ristic et al., 2002). Moreover, the disengage deficit found with left visual neglect patients[2] in spatial cueing tasks, which has been shown to be object-based (Rastelli, Funes, Lupiáñez, Duret, & Bartolomeo, 2008), only occurs in left-neglect in response to arrow cues (Olka, Hildebrand, & Kingstone, 2009); it does not occur when gaze cues are used (Bonato, Priftis, Marenzi, & Zorzi, 2009). These findings therefore suggest that orienting in response to gaze and arrow cues is subserved by different brain areas. Further support for this hypothesis comes from a neuroimaging study that showed that shifts of attention triggered by gaze cues and biologically irrelevant arrow cues rely on different neurological structures (Hietanen, Nummenmaa, Nyman, Parkkola, & Hamalainen, 2006) or at least engage the same areas differentially (Tipper, Handy, Giesbrecht, & Kingstone, 2008). Fn2

The present study supports the view that attentional orienting in response to gaze cues is unique and has implications for how symbolic directional gaze and arrow cues are encoded by the attention system. The property of gaze cues to induce specific location orienting seems an important feature of the joint attention system that is not inherent to the system responsible for arrow cueing. This property may support important functions of the joint attention system; for example, it may support noun acquisition in infants (Charman et al., 2001), and may favor a fast reaction to important events (such as the approach of a predator or the pres-

[2] In the spatial cueing paradigm, Neglect patients—typically with large right parietal lesions—show the longest reaction times when the target appears on the contralesional side following a cue at the ipsilesional side. This effect is often described as an extinction-like pattern, and is interpreted as a deficit in disengaging attention from a right-sided event when attention has to be reengaged on a left-sided object (reviews in Bartolomeo & Chokron, 2002).

ence of a food source) that have just appeared and otherwise would have gone unnoticed.

It will be interesting to test whether this specificity of gaze cues in comparison to arrows is maintained in groups with lower social or theory-of-mind abilities like autistic children. Perhaps they use gaze as arrows, thus showing stimulus or object-driven effects instead of showing an attentional orienting effect exclusively at the location where the observed eyes are looking at.

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Received January 12, 2011
Revision received March 30, 2011
Accepted April 4, 2011 ■