Get real! Resolving the debate about equivalent social stimuli.

Elina Birmingham[1]

Walter F. Bischof[2]

Alan Kingstone[3]

[1]California Institute of Technology

[2] University of Alberta

[3] University of British Columbia

Correspondence to: Elina Birmingham
1200 E. California Blvd
California Institute of Technology
Pasadena, CA 91125
Tel: 626-395-6212
Fax: 626-395-2000
Email: elinab@hss.caltech.edu

Word count (abstract plus body): 6,044

Abstract

Gaze and arrow studies of spatial orienting have shown that eyes and arrows produce nearly identical effects on shifts of spatial attention. This has led some researchers to suggest that the human attention system considers eyes and arrows as equivalent social stimuli. However, this view does not fit with the general intuition that eyes are unique social stimuli nor does it agree with a large body of work indicating that humans possess a neural system that is preferentially biased to process information regarding human gaze. To shed light on this paradox we entertained the idea that the model cuing task may fail to measure some of the ways that eyes are special. Thus rather than measuring the orienting of attention to a location cued by eyes and arrows, we measured the selection by attention for eyes and arrows embedded in complex real-world scenes. The results were unequivocal: people prefer to look at other people and their eyes; they rarely attend to arrows. This outcome was not predicted by visual saliency but it was predicted by the idea that eyes are social stimuli that are prioritised by the attention system. These data, and the paradigm from which they were derived, shed new light on past cuing studies of social attention, and they suggest a new direction for future investigations of social attention.

Our everyday knowledge suggests that we are very interested in the attention of other people. Indeed, experience suggests that as social beings we are quick to notice when people are looking at us; and when they are not looking at us we are quick to determine what they are looking at. This intuition, that we care about where other people are attending, has led to the birth of research in *social attention.*

While there are several cues to the direction of another person's attention (e.g. gaze direction, head position, body position, pointing gestures), the above description suggests that gaze direction has a special status as an attentional cue (Emery, 2000; Langton et al., 2000). Morphologically, the human eye is equipped to promote fast discrimination of gaze direction, having the highest dark iris-to-white sclera contrast of all the primate eyes (Kobayashi & Koshima, 1997). Humans are not only very accurate at discriminating gaze direction (Cline, 1967; Gibson & Pick, 1963; Jaspars et al., 1973; Lord & Haith, 1974), but we also appear to have neural structures that are preferentially biased for processing gaze information. For instance, single cell recordings in monkeys show that the superior temporal sulcus (STS) has cells that are selective for different gaze directions, independent of head orientation (Perrett et al., 1985); and neuroimaging studies (Hoffman & Haxby, 2000; Pelphrey et al., 2004) have similarly shown that the human STS seems to be especially activated by changes in gaze direction. Indeed, eye gaze is thought to be so important that it has been placed as the primary social attention cue in prominent models of social attention (Baron-Cohen, 1995; Perrett et al., 1992).

Perhaps what makes eyes so unique is that in addition to implying where someone's attention is directed, they can be used to infer a wealth of other social information that we use on an everyday basis. For instance, eyes can help us determine what someone is feeling, thinking, or wanting (Baron-Cohen et al., 1997). Eyes are also used to modulate social interactions, by facilitating conversation turn-taking, exerting social dominance, and signalling social defeat or appeasement (Argyle & Cook, 1976; Dovidio & Ellyson, 1982; Ellsworth, 1975; Exline, 1971; Exline et al., 1975; Kendon, 1967; Kleinke, 1986; Lochman & Allen, 1981). Thus, both intuition and empirical evidence suggest that eyes are extremely important and unique social-communicative stimuli.

To measure the unique social importance of eyes, an abundance of research has examined the extent to which gaze direction can trigger an attention shift in others (what is sometimes called 'joint attention'). Using the model gaze cuing task it is well-established that infants (Hood, Willen & Driver, 1998; Farroni et al., 2000), preschool children (Ristic, Friesen & Kingstone, 2002) and adults alike (Driver et al., 1999; Friesen & Kingstone, 1998; Langton & Bruce, 1999) will shift attention automatically to where others are looking. In the typical gaze cuing paradigm a participant is first shown a picture of a real or schematic face with the eyes looking either to the left or to the right. A target is then presented either at the gazed-at location or at the opposite location. The usual finding is that response time (RT) to detect a target is fastest when the target appears at the gazed-at (cued) location, consistent with the notion that attention was shifted there in response to where the gaze cue was looking. Because this effect emerges rapidly and occurs even when gaze direction does not predict where a target is going to appear, it is considered to measure *reflexive* orienting of attention to gaze direction.

This automatic gaze-cuing effect was initially thought to be an effect that was unique to gaze, with other, well-learned directional stimuli, like arrows, failing to produce a reflexive attention effect (Jonides, 1981). It was therefore something of a shock when Ristic et al. (2002) and Tipples (2002) reported in separate investigations that central, spatially nonpredictive arrow cues produce a robust reflexive orienting effect; and Ristic et al. (2002) mapped out the time course of this attention effect for eyes and arrows showed that they were very similar.

A number of subsequent studies have confirmed that the arrow cuing effect is very similar to the gaze cuing effect (e.g., Gibson & Bryant, 2005; Hommel, Pratt, Colzato, & Godijn, 2001; Ristic, Wright & Kingstone, 2007; Gibson & Kingstone, 2006; see also Eimer, 1997). Indeed, even some of the more subtle attention effects that were initially thought to be unique to gaze cues have now been shown to occur for arrow cues as well. For instance, it was initially thought that only gaze cues produce reflexive orienting to a location despite observers' intention to shift attention volitionally somewhere else (Driver et al., 1999; Friesen, Ristic & Kingstone, 2004). However, Tipples (2008) has shown convincingly that arrows, too, can produce this reflexive attention effect.

Similarly, brain lesion and neuroimaging studies indicated initially that gaze and arrow cues engage different underlying neural systems (Hietanen et al., 2006; Kingstone et al., 2000; Ristic et al., 2002; Vuilleumier, 2002). However, when physical differences between the cues are controlled, gaze and arrow cues appear to engage the same brain systems (Tipper et al., 2008).

This convergence between gaze and arrow cues extends to overt shifts of attention. Ricciardelli et al. (2002) found that when participants were asked to make a speeded eye movement to the left or right of fixation, as indicated by a central square stimulus, correct saccade latencies were fastest on trials that a face gazed in the congruent (same) direction. A similar effect occurred for when an arrow replaced the gaze stimulus. However, only the *incongruent gaze* stimulus produced unwanted saccades toward the incorrect location; *incongruent arrows* failed in this respect. In a follow-up study, Kuhn and Benson (2007) implemented the same saccade paradigm as Ricciardelli et al., but used more traditional, "arrow-like"cues than did Ricciardelli et al. (who used simple arrowheads, e.g., < >). Kuhn and Benson found that both incongruent gaze and arrow stimuli trigger incorrect saccades; although the response latency for incorrect saccades appeared to be somewhat shorter for gaze stimuli than for arrow stimuli. Recently, however, this error latency difference between eyes and arrows was found to be unreliable (Kuhn and Kingstone, in press).

Collectively, the data suggest the conclusion that gaze and arrow stimuli have essentially the same effect on spatial attention. That is, even though we have an intuition that eye gaze is a special attentional stimulus, behavioral and neural evidence indicate that humans shift their attention in response to eyes and arrows in much the same way, and that this applies to both covert and overt orienting.

The broader implications of this conclusion are not altogether clear. Certainly, the finding that arrow cues produce near identical effects to gaze cues runs counter to our intuition that eyes are unique, special social attention stimuli. However, it could be simply that arrows are also important social stimuli, which explains why they, too, have the same effect on attention as eyes. This potential status of arrows has not been overlooked. For example, Kingstone et al. (2003) wrote "arrows are obviously very directional in nature, and, like eyes, they have a great deal of social significance. Indeed, it is a challenge to move through one's day without encountering any number of arrows on signs and postings" (p. 178).

This interpretation of the gaze and arrow cue data is reasonable if one accepts the basic assumption that the gaze/arrow cuing paradigm taps into social attention mechanisms. An alternative, and theoretically more radical position however is that gaze cues and arrow cues produce similar orienting in the cuing paradigm because the cuing paradigm is not measuring social attention. In other words, eyes and arrows are extremely different social stimuli, but the cuing paradigm is failing to capture key aspects about eyes that distinguish them as unique social stimuli. According to this view, the cuing paradigm is merely measuring eyes and arrows on a dimension that they are highly similar -- their ability to communicate directional information such as left and right (Gibson & Kingstone, 2006). It is like taking a 150-pound person and a 150-pound rock, weighing them, and concluding that they are the same. They are the same, in terms of weight, but there is the intuition that they are not the same in many other ways. To demonstrate that, however, one would need a different way to measure the person and the rock, i.e., a different research approach would be called for. In much the same way, what may be needed in the area of social attention is a different research approach -- one that better reflects our intuition that the human attention system cares about eyes in a way that is distinct from other stimuli in the environment. One possible avenue has recently been suggested by Kuhn and Kingstone (in press): "although arrows and eye gaze may be of equal relevance when they are presented to the participant in isolation, key differences between social and non social cues may only become apparent when they are embedded within a richer environment." (p. 41).

An alternative research approach

An alternative approach for studying social attention is provided by considering the different components of attention that can be measured in experiments involving social stimuli. Importantly, both gaze and arrow cuing studies are specifically designed to test one particular component of visual attention: *spatial orienting*. However, spatial orienting in response to a cue is only one component of attention. The *selective* component of attention, that is, the initial commitment of attention to one aspect of the environment rather than another, is not strongly represented by these cuing studies. Consider a real world example of social attention: You are riding a bicycle on campus and notice that your colleague is standing on the sidewalk and looking at something on the ground. Using her gaze direction you orient your attention to see what she is looking at. It is clear from this example that there are at least two distinct components of attention: first, you *select* your colleague's eyes as a key social stimulus, and second, you *shift* your attention from her eyes to the location/object that she is looking at. Gaze and arrow cuing studies focus exclusively on how gaze and arrow cues affect the spatial orienting (shift) component of attention. As such, these studies do not inform us about the initial selection of gaze and arrow cues from the environment. Indeed, because cuing studies are solely interested in the orienting aspect of attention, the experimenter essentially *preselects* the cue and places it at fixation (the current focus of attention).

The aim of the present study was to examine whether this equivalence between eyes and arrows will hold when the *selection* component of social attention is measured. Specifically, will eyes and arrows be given equal priority when participants are provided with the opportunity to freely select stimuli from a complex real-world visual scene?

The fact that no studies have compared the selection of eyes versus arrows in complex settings is noteworthy given the strong tradition of research on selective attention (e.g., James, 1890, Broadbent, 1958, 1972; Deutsch & Deutsch, 1963; Moray, 1959; Neisser, 1967; Treisman, 1960). The basic assumption behind all these conceptualizations of selective attention is that humans possess a capacity limitation when it comes to handling information in the world. The implication of this capacity limitation is that we must select some items for processing at the expense of others (hence the term *selective* attention). Research on scene perception has consistently shown that when presented with a complex scene, observers tend to select (fixate) items that are informative (Buswell, 1935; Henderson et al., 1999; Loftus & Mackworth, 1978; Yarbus, 1967). When people are absent from visual scenes, this means that observers will look primarily at objects that add semantic meaning to the scene and scene regions with high amounts of visual information (Antes, 1974; Buswell, 1935; Henderson et al., 1999; Loftus & Mackworth, 1978). When people are present in a scene, observers look primarily at the eyes and faces of the people and devote less attention to the rest of the scene (Birmingham et al., 2008a, 2008b; Yarbus, 1967). This suggests that when a person is presented in a scene, their eyes become important to understanding the scene. We have interpreted these findings as indicating that people fixate the eyes of others because they perceive the eyes to contain important social information. In support of this, observers' preference for eyes is enhanced by social tasks (e.g. describe where people in the scene are directing their attention) and by increasing the social content and activity of a scene (e.g. increasing the number of people actively doing something (Birmingham et al., 2008b). Thus there is evidence suggesting that observers preferentially select gaze information from a complex scene, and that this reflects the fact that eyes are perceived to be informative social stimuli.

However, no studies have tested whether gaze would be preferentially selected if an arrow were also placed in the scene. Research using the cuing paradigm indicates that eyes and arrows are equivalent attentional cues, and that this reflects the fact that arrows, like eyes, are socially significant. One possible outcome then is that eyes and arrows will be selected to the same extent. An alternative possibility is that eyes will be preferentially selected over arrows. This finding would suggest that eyes and arrows do not have equal social relevance, and would dovetail with the general intuition that while eyes and arrows are both directional, eyes are unique in that they can communicate other social information, such as the emotion, intention, state of mind, and ages of other people. As such, eyes may be prioritized by the attention system. This outcome is not predicted by past gaze and arrow cuing studies.

Method

The present study examined the extent to which eyes and arrows are selected from complex scenes. We presented a variety of photographs of real world scenes containing both people and arrows, and monitored observers' eye movements while they freely viewed the scenes. This allowed us to determine how often, and how quickly, observers select eyes and arrows.

Participants

Fifteen undergraduate students from the University of British Columbia participated in this experiment. All had normal or corrected to normal vision, and were naïve to the purpose of the experiment. Each participant received course credit for participation in a one-hour session.

Apparatus

Eye movements were monitored using an Eyelink II tracking system. The on-line saccade detector of the eye tracker was set to detect saccades with an amplitude of at least 0.5°, using an acceleration threshold of $9500°/s^2$ and a velocity threshold of 30°/s.

Stimuli

Full colour photographs were collected from various sites on the world wide web.

Each picture was presented on a white 800 × 600 pixel canvas. Thus, in some cases, a picture that was slightly smaller than 800 × 600 pixels was surrounded by the white borders of the canvas. Image (canvas) size was 36.5 x 27.5 (cm) corresponding to 40.1° x 30.8° at the viewing distance of 50 cm. Twenty three images were used in the present experiment: six images contained both people and arrows, one image contained arrows but no people, and sixteen remaining 'filler' images were displayed (containing photographs of people, faces, and paintings). The critical seven arrow images analyzed in the present experiment are shown in Figure 1 (left column).

--Figure 1--

Procedure

Participants were seated in a brightly lit room, and were placed in a chin rest so that they sat approximately 50 cm from the display computer screen. Participants were told that they would be shown several images, each one appearing for 15 seconds, and that they were to simply look at these images.

Before beginning the experiment, a calibration procedure was conducted. Participants were instructed to fixate a central black dot, and to follow this dot as it appeared randomly at nine different places on the screen. This calibration was then validated, a procedure that calculates the difference between the calibrated gaze position and target position and corrects for this error in future gaze position computations. After successful calibration and validation, the scene trials began.

At the beginning of each trial, a fixation point was displayed in the centre of the computer screen in order to correct for drift in gaze position. Participants were instructed to fixate this point and then press the spacebar to start a trial. One of 23 pictures was then shown in the center of the screen. Each picture was chosen at random and without replacement. The picture remained visible until 15 seconds had passed, after which the picture was replaced with the drift correction screen. This process repeated until all pictures had been viewed.

Results

Data handling

In keeping with previous reports (e.g., Smilek et al., 2006; Birmingham et al., 2008a, 2008b) the data were handled in the following manner. For each image, an outline was drawn around each region of interest (e.g. "eyes", “arrow”) and each region’s pixel coordinates and area were recorded. We defined the following regions in this manner: eyes, heads, body (including arms, torso and legs), arrows, and ‘other’.

To determine what regions were of most interest to observers we computed *fixation proportions* by dividing the number of fixations for a region by the total number of fixations over the whole display. We corrected for area differences between regions and across scenes to control for the fact that large regions would, by chance alone, receive more fixations than small regions. This was accomplished by dividing the proportion score for each region by its area. These data are shown in Table 1.

To determine where observers’ initial saccades landed in the visual scene, we computed the number of first fixations that landed in a region (*initial fixations*). These data were not area-corrected and are shown in Table 1

To determine whether low-level properties of the scene -- that is, *visual saliency* -- could account for where observers committed their first fixation to the scene, we computed saliency maps according to Itti and Koch’s (2000) model. Itti and Koch measure visual saliency of an image by identifying strong changes in intensity, colour and local orientation. The software is provided by Laurent Itti at [http://ilab.usc.edu/toolkit/downloads.shtml]. As visual saliency is thought to have its greatest impact on the first saccade (Henderson, Weeks, & Hollingworth, 1999; Parkhurst et al., 2002) we focused our analysis on initial fixations. We computed the average saliency of fixated scene locations and compared this average saliency of random locations sampled from the smoothed probability distribution of all first-fixation locations from participants’ eye movement data across all scenes. This control value was chosen to account for the known bias to fixate the lower central regions of scenes. This comparison allowed us to determine whether the saliency model accounted for first fixation position above what would be expected by chance.

<u>Fixation proportions</u>

Scenes with eyes and arrows: Our main question of interest was whether eyes and arrows would be fixated to the same extent. Thus, we analyzed the images containing both eyes and arrows, i.e. images with people who were large enough for the observer to see the eye region (Figure 1,A-C). The middle column of Figure 1 (A-C) shows fixation plots for all subjects for these three images. Immediately noticeable from these plots is that observers concentrated their fixations primarily on the people, particularly their eyes. Observers rarely fixated the arrows.

To confirm these impressions, we conducted a Repeated Measures ANOVA on fixation proportions (see Table 1) with Region (eyes, heads, bodies, text, arrows, and 'other' (the remainder of the scene)) as a factor. This analysis revealed a highly significant effect of Region ($F(5,70)=50.98$, $p<0.0001$). Pairwise comparisons (Tukey-Kramer multiple comparisons test) revealed that observers fixated the eyes more than any other region ($p<0.05$). The next most frequently fixated regions were heads and text which were fixated more than bodies and arrows, and the rest of the scene, p's<0.05. Confirming our impression from Figure 1, arrows were not fixated often in these scenes. Thus, to answer the main question of our study, eyes were fixated far more frequently than arrows, which were hardly fixated at all.

--Table 1--

Scenes with larger arrows: One might wonder if observers failed to show a preference for arrows in the previous analysis because they were relatively inconspicuous given that they were smaller than the people in the scene (Figure 1, scenes A-C). To address this issue we analyzed three other scenes in which the arrows were large and the people were small (indeed, their eyes were not even visible) (Figure 1, D-F). Fixation plots for these images are shown in Figure 1 (D-F, middle column). Again, it is immediately noticeable that observers focused mostly on the people, particularly the heads of the people, and that few fixations were committed to the arrows. Even the empty bench in Scene E, where people would be expected, received more fixations than the arrows in the scene. For these scenes, we analyzed fixation proportions as a function of Region (heads, bodies, bench, arrows, other). Note that the eyes were not visible because the people were small (also because of the viewing angle) and thus eyes were not analyzed. The ANOVA revealed an effect of Region ($F(4,56)=83.62$, $p<0.00001$), with heads being fixated more than any other region (Tukey Kramer, $p<0.05$). Bodies were the next most fixated, and more so than benches, arrows and other items, all p's<0.05 (see Table 1). Thus, despite their very large size, arrows were again fixated infrequently relative to the people. (Note that as the data are *proportions* of fixations as a function of region, one cannot directly compare the data for Scenes D-F to Scenes A-C, as the content of the scenes (and thus the regions of interest) are not constant; however it is unequivocal that in all cases fixations were committed preferentially to eyes when they were available, and frequently to heads when eyes were not available; and in all cases fixations were rarely committed to arrows.

Scenes with no people: The results thus far have demonstrated that observers care very little about arrows placed in scenes containing people. It appears that as social beings, observers allocate their attention primarily to other people, particularly their eyes and heads. What happens when no people are in the scene? Given that arrows have been thought of as socially relevant objects (Kingstone et al., 2003; Tipples, 2002), would they receive preferential attention when placed among other objects when there are no people present? We analyzed the data for the scene in Figure 1(G). For the analysis the scene was parsed into four regions: the 'no–entry' sign, the drawing of grapes, the arrow, and other (remaining items of the scene). The fixation plot in Figure 1(G) shows that relative to both the no-entry sign and the grapes, the arrow was fixated infrequently. The data are summarized in Table 1. An ANOVA on the fixation proportions revealed an effect of Region ($F(3,42)=135.78$, $p<0.00001$), with pairwise comparisons revealing that observers looked mostly at the no-entry sign than any other region (Tukey-Kramer, $p<0.05$). The next most fixated region was 'grapes', which was fixated more than the arrow, $p<0.05$. All three of these regions were fixated more often than the remainder of the image (other), $p<0.05$. These data suggest that observers show little interest in the arrow relative to other main scene items.

Initial fixations

Scenes with eyes and arrows: Although the fixation proportions showed that eyes were fixated more frequently than arrows, these were averaged over the entire viewing period. Thus, the analyses of fixation proportions might reflect more voluntary or strategic viewing patterns that developed over time. The very first fixation, on the other hand, reveals which regions attract attention immediately upon the appearance of the scene. We reasoned that if arrows capture attention as strongly as eyes, then this would be reflected in the first fixation being just as likely to land on an arrow as an eye region. Thus, we analyzed the proportion of first fixations (the first fixation after the experimenter-controlled fixation at centre) that landed on eyes, heads, bodies, arrows, or other (see Table 1). These data were not area normalized. There was a significant effect of Region ($F(5,70)=3.61$, $p<0.01$), with eyes, heads, text, and the remainder of the scene all equally likely to receive the first fixation, and all more likely than the arrow, which never received the first fixation (Tukey-Kramer, $p<0.05$).

Scenes with larger arrows: Larger arrows were also never fixated first (Table 1). An ANOVA revealed an effect of Region, $F(4,56)=9.33$, $p<0.0001$. Bodies and other were both most likely to get the first fixation, more so than any other region, (Tukey-Kramer, $p<0.05$). As with scenes containing smaller arrows, larger arrows never received the first fixation.

Scenes with no people: Are arrows fixated first when people are absent? Which regions of Scene G are most likely to be fixated first? An ANOVA revealed an effect of Region (no-entry, grapes, arrow, other), ($F(3,42)=70.38$; $p<0.0001$). The grapes were highly likely to be fixated first, and more so than the no-entry sign (Tukey-Kramer, $p<0.05$). The arrow and the rest of the scene were never fixated first.

Visual Saliency

Saliency of the location of subjects' first fixations was compared to a chance-based estimate (called *biased-random*) that takes into account the bias to fixate the lower central regions of the scene. Figure 1 (right column) shows all observers' first fixations overlaid on the saliency maps of each image. To determine whether the saliency model accounted for first fixation position above what would be expected by chance, non-parametric statistics (Mann-Whitney U tests) were performed to compare the medians of *fixated* saliency and *biased-random* saliency.

The fixated saliency was very low (0.0022), and was no different from biased-random saliency (0.0027; $p>0.50$). Thus, saliency at fixated locations was no higher than would be expected by chance. In fact, observers generally fixated non-salient regions in the scenes. Figure 1 demonstrates this nicely, showing that fixations tended to land on the black parts of the saliency map.

Discussion

The aim of present study was to determine whether eyes and arrows are selected to the same extent within complex scenes. While gaze cuing studies have found that directional gaze and arrow cues have similar effects on *spatial orienting*, these studies do not inform us whether the attentional system also *selects* eyes and arrows to the same extent. We reasoned that measures of selection might be more sensitive to the unique social importance of eyes than the cuing paradigm, and as such might reveal an attentional (selection) priority for eyes over arrows.

One possibility was that observers might select arrows as often as eyes. This would be consistent with research using the cuing paradigm showing that gaze and arrows are equivalent attentional cues, suggesting that they are of equal social relevance. An alternative possibility was that eyes would be preferentially selected over arrows. This finding would suggest that eyes and arrows do not have equal social relevance, and would be in line with the general intuition that while eyes and arrows are equally good at conveying directional information, eyes are special social stimuli because, for example, unlike arrows, they can communicate other important social information about people such as their age, identity, emotions, and inner attentional states. As such, one would expect humans to prioritize information from eyes over arrows.

The results of the present study were clear. When both eyes and arrows were visible in a scene, the majority of fixations went to the eyes, and very few went to the arrows (Table 1). Furthermore, an analysis of the first fixation made to the scene revealed that observers never fixated an arrow first. Instead, they were equally likely to fixate the eyes, heads, and text on the first fixation. This finding suggests that when presented in scenes with eyes, arrows do not capture attention, but eyes (and heads and text) do. As the viewing session proceeded, observers continued to show interest in the people, particularly their eyes, and continued to largely ignore the arrows.

A general preference for people persisted in scenes in which the arrow was large and the people were small. We were interested in whether making the arrow large in comparison to the people, and reducing the eye information in the scene, would enable arrows to be prioritized. However, in those images, the arrows were again rarely fixated. Instead, the heads were fixated the most frequently overall. Again, the arrows were never fixated first. Thus, even when arrows were large, and eyes were unavailable, arrows did not receive many fixations overall relative to the people in the scene.

We were also interested in exploring whether an arrow would be preferentially selected when placed in a scene without people. Given that arrows have been thought of as social tools (Kingstone et al., 2003), one might expect them to receive more attention than other, presumably less social objects (as intuited, for instance, from the gaze/arrow cuing literature). Thus, we showed an image of a road sign with other graphic components (a ‘no-entry’ symbol and a bunch of grapes). However, the data revealed that observers again fixated the arrow less often than the other elements of the scene. In addition, the arrow was never fixated first, but the grapes often were. Thus, while this is a single scene, the initial data suggest that even when arrows are placed within a scene without people, they do not receive much attention.

Finally, we analyzed the contribution of visual saliency to observers’ fixation placement. The saliency at fixated locations was remarkably low, and no higher than what would be expected by chance. This agrees with other recent studies suggesting that visual saliency provides a poor account of eye fixation patterns in complex visual scenes (Cerf et al., 2008; Henderson, Brockmole, Castelhano, and Mack, 2007).

There are several important implications of the present findings. First, to answer the main question of the study, when eyes and arrows are presented within complex scenes and observers are allowed to select items for further processing, observers show a profound preference to select eyes rather than arrows. This is consistent with the neural evidence that humans possess brain mechanisms that are preferentially biased to processing eyes (e.g., Hoffman & Haxby, 2000; Pelphrey et al., 2004). Thus, while eyes and arrows are equally good at conveying directional information, and hence produce equivalent effects on shifts of spatial attention within the cuing paradigm, they are not given equal priority by the attention system via selection within complex scenes. On the contrary, observers show a bias to select information from people’s eyes.

Second, arrows were not only selected less often than eyes, they were typically selected less often than most other scene regions. This was true even when the arrows were large, and when people were absent from the scene. What makes this finding interesting is that even though it is clear that an arrow will produce reflexive shifts of attention within the context of the cuing paradigm, observers show very little interest in arrows within the context of complex scenes. One interpretation of these findings is that the importance of arrows as social communicative tools may be restricted to situations in which direction or location information is task relevant (e.g. following an exit sign on the highway; determining which lane is the turning lane, etc.). Indeed, the cuing paradigm is just that – a situation in which the task is to detect a target at a location on the screen. In that situation, even though arrow direction is not spatially informative about where the target will appear, spatial location is a task relevant dimension, i.e. the only factor over which the target may vary is its spatial position, and the only factor over which the cue may vary is whether it is spatially congruent or incongruent with the target.

A third implication of the present study is that despite a general preference to select people from complex scenes, there appears to be a hierarchy to the selection of 'people parts'. If the people are large enough so that the eyes are visible, observers will concentrate their fixations on the eyes, followed by the heads, and then the bodies. If the people are too small for the eyes to be discriminated, then observers will concentrate their fixations on the heads, followed by the bodies. Thus, while there is a general preference for people, observers preferentially fixate the eyes if they are available, then heads, then bodies. This is consistent with Perrett et al.'s (1992) model of social attention, in which gaze is at the top of a hierarchy of social attention cues, followed by head position and then body position.

Fourth, in light of the data indicating an enormous preference to select eyes over arrows, we can return to our initial consideration of the cuing literature, which indicates that eyes and arrows are equivalent social cues. This position must be rejected. We favour the alternative view that the similarity between gaze and arrow cues within the cuing paradigm occurs because the cuing paradigm is not sensitive to the social value of eyes relative to arrows. Indeed, because similar cuing effects are found for gaze, arrows, words (Hommel et al., 2001), and even wagging tongues (Downing et al., 2004), it appears that the cuing paradigm merely encourages participants to use the directional information conveyed by the cues, and not their social information.

We do not mean to suggest that the spatial orienting (shift) stage of social attention is unimportant. What we are suggesting, however, is that the gaze cuing paradigm may not be measuring this process. We feel that a more favorable research approach is one that tries to measure social attention in more real-world settings, in which gaze direction is one of several stimuli that make up a rich social context. For instance, Kuhn and Land (2006) showed that the vanishing ball illusion, in which a ball is perceived to have vanished in mid air, relies strongly on social attention cues from the magician performing the trick. That is, when the magician pretends to toss a ball upward but secretly conceals the ball in the palm of his hand, observers are much more likely to perceive the ball traveling upward and vanishing when the magician looks upward with the fake toss than when he looks down at his hand. Furthermore, on real throws on which the ball is physically present, instead of simply tracking the ball with their eyes, observers often make fixations to the magician's face before looking at the ball. This suggests that observers select information about the magician's attention in order to predict the position of the ball. Kuhn and Land's study thus provides an excellent example of how social attention, both with regard to the *selection* and *orienting* components of attention, can be studied successfully using rich, complex stimuli.

References

Antes, J.R. (1974). The time course of picture viewing. *Journal of Experimental Psychology*, 103(1), 62-70.

Argyle, M., & Cook, M. (1976). *Gaze and mutual gaze*. Cambridge, England: Cambridge University Press.

Baron-Cohen, S., Baldwin, D. A., & Crowson, M. (1997). Do children with autism use the speaker's direction of gaze strategy to crack the code of language? *Child Development*, 68,48 –57.

Baron-Cohen, S. (1995) *Mindblindness: An Essay on Autism and Theory of Mind*, MIT Press.

Birmingham**,** E., Bischof, W.F., & Kingstone, A. (2008a). Social attention and real world scenes: the roles of action, competition, and social content. *Quarterly Journal of Experimental Psychology, 61(7), 986-998.*

Birmingham**,** E., Bischof, W.F., & Kingstone, A. (2008b). Gaze selection in complex social scenes. *Visual Cognition,* 16(2/3), 341-355.

Broadbent, D.E. (1958). *Perception and Communication*. Pergamon Press, London.

Broadbent, D.E., (1972). *Decision and stress*. Academic Press, New York.

Buswell, G.T. (1935). *How people look at pictures*. University of Chicago Press, Chicago.

Cerf, M., Harel, J., Einhäuser, W., and Koch, C. (2008). Predicting human gaze using low-level saliency combined with face detection. In Platt, J., Koller, D., Singer, Y. & Roweis, S. (Eds.), *Advances in Neural Information Processing Systems,* 20, MIT Press, Cambridge, MA.

Cline, M.G. (1967). The perception of where a person is looking. *American Journal of Psychology.* 80, 41–50.

Dovidio, J.F. and Ellyson, S.L. (1982). Decoding visual dominance: Attributions of power based on relative percentages of looking while speaking and looking while listening. *Social Psychology Quarterly*, 43, 106–113.

Downing, C.J. and S. Pinker, (1985). 'The spatial structure visual attention'. In: M. Posner and 0. Marin (eds.), Attention and performance XI. Hillsdale, NJ: Erlbaum Eriksen and Hoffman 1973; Posner.

Downing, P.E., Dodds, C.M., & Bray, D. (2004). Why does the gaze of others direct visual attention? *Visual Cognition*, 11, 71-79.

Driver, J., Davis, G., Ricciardelli, P., Kidd, P., Maxwell, E., & Baron-Cohen, S. (1999). Gaze perception triggers visuospatial orienting by adults in a reflexive manner. *Visual Cognition*, 6, 509-540.

Deutsch J A & Deutsch D. (1963). Attention: some theoretical considerations. *Psychological Review*. 70, 80-90.

Ellsworth, P.C., (1975). Direct gaze as a social stimulus: the example of aggression. In Pliner, P., Krames, L. and Alloway, T., (Eds), *Nonverbal Communication of Aggression*, Plenum, New York, pp. 71–89.

Eimer, M. (1997). Uninformative symbolic cues may bias visual-spatial attention: Behavioral and electrophysiological evidence. *Biological Psychology,* 46, 67-71.

Emery, N.J. (2000). The eyes have it: the neuroethology, function and evolution of social gaze. *Neuroscience and Biobehavioral Reviews*, 24, 581-604.

Exline, R. (1971). Visual interaction. The glances of power and preferences, *Nebraska Symposium on Motivation,* 19*,* 163-206.

Exline, R. V., Ellyson, S. L., & Long, B. (1975). Visual behavior as an aspect of power role relationships. In P. Pliner, L. Krames, & T. AIIoway (Eds.), *Nonverbal communication of aggression* (pp. 21-52). New York: Plenum Press

Farroni, T., Johnson, M. H., Brockbank, M, & Simion, F. (2000). Infants' use of gaze direction to cue attention: The importance of perceived motion. *Visual Cognition,* 7, 705-718.

Friesen, C. K., & Kingstone, A. (1998). The eyes have it!: Reflexive orienting is triggered by nonpredictive gaze. *Psychonomic Bulletin & Review,* 5, 490-495.

Friesen, C. K., Ristic, J., & Kingstone, A. (2004). Attentional effects of counterpredictive gaze and arrow cues. *Journal of Experimental Psychology: Human Perception & Performance,* 30, 319-329.

Gibson, B.S., Kingstone, A., (2006). Visual attention and the semantics of space: Beyond central and peripheral cues. *Psychological Sciience*, 17, 622-627.

Gibson B. S., & Bryant T. A. (2005). Variation in cue duration reveals top-down modulation of involuntary orienting to uninformative symbolic cues. *Perception & Psychophysics*, 67, 749-758.

Gibson, J.J. and Pick, A. (1963) Perception of another person's looking. *American Journal of Psychology.* 76, 86–94.

Henderson, J.M., Brockmole, J.R., Castelhano, M.S. & Mack, M. (2007). Visual saliency does not account for eye movements during visual search in real-world scenes. In van Gompel, R., Fisher, M., Murray, W., & Hill, R. (Eds), *Eye movement research: insights into mind and brain*. Elsevier.

Henderson J.M., Weeks P.A. Jr, & Hollingworth, A. (1999). The effects of semantic consistency on eye movements during scene viewing. *Journal of Experimental Psychology: Human Perception and Performance,* 25(1)*,* 210-228.

Hietanen, J. K., Nummenmaa, L., Nyman, M. J., Parkkola, R., & Hämäläinen, H. (2006). Automatic attention orienting by social and symbolic cues activates different neural networks: An fMRI study. *Neuroimage*, 33, 406-413.

Hoffman, E., A., & Haxby, J., V. (2000). Distinct representations of eye gaze and identity in the distributed human neural system for face perception. *Nature Neuroscience,* 3, 80-84.

Hommel, B., Pratt, J., Colzato, L. & Godijn, R. (2001). Symbolic control of visual attention. *Psychological Science,* 12, 360-365.

Hood, B.M., Willen, J.D., & Driver, J. (1998). Adult's eye trigger shifts of visual attention in human infants. *Psychological Science*, 9,131-134.

Itti., L., & Koch, C. (2000). A saliency-based search mechanism for overt and covert shifts of visual attention. *Vision Research*, 40, 1489-1506.

James, W. (1890). *Principles of Psychology,* H. Holt & Co.

Jonides, J. (1981) Voluntary versus automatic control over the mind's eye's movement. In Field, T. & Fox, N. (Eds.), *Attention and Performance Vol. IX*, pp. 187–203, Erlbaum .

Kendon, A. (1967). Some functions of gaze-direction in social interaction. *Acta Psychologica*, 26. 22-63.

Kingstone, A., Friesen, C. K., & Gazzaniga, M.S., (2000). Reflexive joint attention depends on lateralized cortical connections. *Psychological Science,* 11, 159-166.

Kingstone, A., Smilek, D.,Ristic, J., Friesen, C. K. & Eastwood, J. D. (2003). Attention, researchers! It's time to pay attention to the real world. *Current Directions in Psychological Science*, 12, 176-180.

Kleinke, C. L. (1986). Gaze and eye contact: A research review. *Psychological Bulletin*, 100, 78-100.

Kobayashi, H. and Kohshima, S. (1997). Unique morphology of the human eye. *Nature,* 387, 767–768.

Kuhn, G. & Benson, V. (2007). The influence of eye-gaze and arrow pointing distractor cues on voluntary eye movements. *Perception & Psychophysics*, 69(6), 966-971.

Kuhn, G., & Kingstone, A. Look away! Eyes and Arrows Engage Oculomotor Responses Automatically. In press at *Perception & Psychophysics.*

Kuhn, G. & Land, M. F. (2006). There's more to magic than meets the eye! *Current Biology*. 16 (22), R950-R951.

Langton, S.R.H. & Bruce, V. (1999). Reflexive visual orienting in response to the social attention of others. *Visual Cognition.* 6, 541–568

Langton, S.R.H. Watt, R. J., & Bruce, V. (2000). Do the eyes have it? Cues to the direction of social attention. *Trends in Cognitive Sciences,* 4, 50–58.

Lochman, J. E., & Allen, G. (1981). Nonverbal communication of couples in conflict. *Journal of Research in Personality,* 15, 253-269.

Loftus, G.R., Mackworth, N.H. (1978). Cognitive determinants of fixation location during picture viewing. *Journal of Experimental Psychology. Human Perception and Performance*, 4(4), 565-572.

Lord, C. and Haith, M.M. (1974). The perception of eye contact. *Perception and Psychophysics*, 16, 413-416.

Moray, N. (1959). Attention in dichotic listening: Affective cues and the influence of instructions. *Quarterly Journal of Experimental Psychology*, 11, 56-60.

Neisser, U. (1967). *Cognitive psychology.* New York: Appleton-Century-Crofts.

Pelphrey, KA., Viola, RJ., & McCarthy, G. (2004). When Strangers Pass: Processing of Mutual and Averted Social Gaze in the Superior Temporal Sulcus. *Psychological Science*, 15, 598- 603.

Perrett, D. I., Hietanen, J. K., Oram, M. W., & Benson, P. J. (1992). Organisation and functions of cells responsive to faces in the temporal cortex. *Philosophical Transactions of the Royal Society of London, Series B*, 335, 23–30.

Ricciardelli, P., Bricolo, E., Aglioti, S. M., & Chelazzi, L. (2002). My eyes want to look where your eyes are looking: Exploring the tendency to imitate another individual's gaze. *Neuroreport*, 13(17), 2259-2264.

Ristic, J., Friesen, C. K., & Kingstone, A. (2002). Are eyes special? It depends on how you look at it. *Psychonomic Bulletin & Review, 9*, 507-513.

Ristic, J., Wright, A. & Kingstone, A. (2007). Attentional control and reflexive orienting to gaze and arrow cues, *Psychonomic Bulletin & Review,* 14*,* 964-969.

Tipper, C., Handy, T., Giesbrecht, B. & Kingstone, A. (2008). Brain responses to biological relevance. *Journal of Cognitive Neuroscience,* 20(5), 879–891.

Tipples, J. (2002). Eye gaze is not unique: Automatic orienting in response to noninformative arrows. *Psychonomic Bulletin & Review,* 9, 314-318.

Tipples, J. (2008). Orienting to counterpredictive gaze and arrow cues. *Perception & Psychophysics*, 70, 77-87.

Treisman A M. (1960). Contexual cues in selective listening. *Quarterly Journal of Experimental Psychology,* 12, 242-248.

Vuilleumier, P. (2002). Perceived gaze direction in faces and spatial attention: a study in patients with parietal damage and unilateral neglect. *Neuropsychologia*, 40 (7), 1013-1026.

Yarbus, A. L (1967). *Eye movements and vision* (B. Haigh,Trans.). New York: Plenum Press. (Original work published 1965).

Table 1. Proportion of all fixations landing in each region (Fixation proportion), and proportion of all first fixations landing in each region (Initial fixations).

Scene Type	Region	Fixation proportion	Initial fixations
Eyes and arrows	Eyes	0.45	0.20
	Heads	0.23	0.20
	Bodies	0.05	0.13
	Text	0.21	0.22
	Arrow	0.05	0.00
	Other	0.01	0.24
Large arrows	Heads	0.51	0.07
	Bodies	0.33	0.40
	Bench	0.09	0.13
	Arrow	0.05	0.00
	Other	0.02	0.40
No people	No-entry	0.53	0.07
	Grapes	0.27	0.93
	Arrow	0.17	0.00
	Other	0.03	0.00

Figure Captions

Figure 1. Left: The scenes used in the experiment. A-C: Scenes with eyes and arrows, D-F: Scenes with large arrows, G: Scene without people. Middle: Overlays from all observers' fixations. There was a clear preference for the people in the scene, particularly their faces and eyes. Fewer fixations went to the arrows. Right: Saliency maps for each scene, with first fixations from all observers. First fixations tended to land on the non-salient areas of the scene (black in the saliency map).

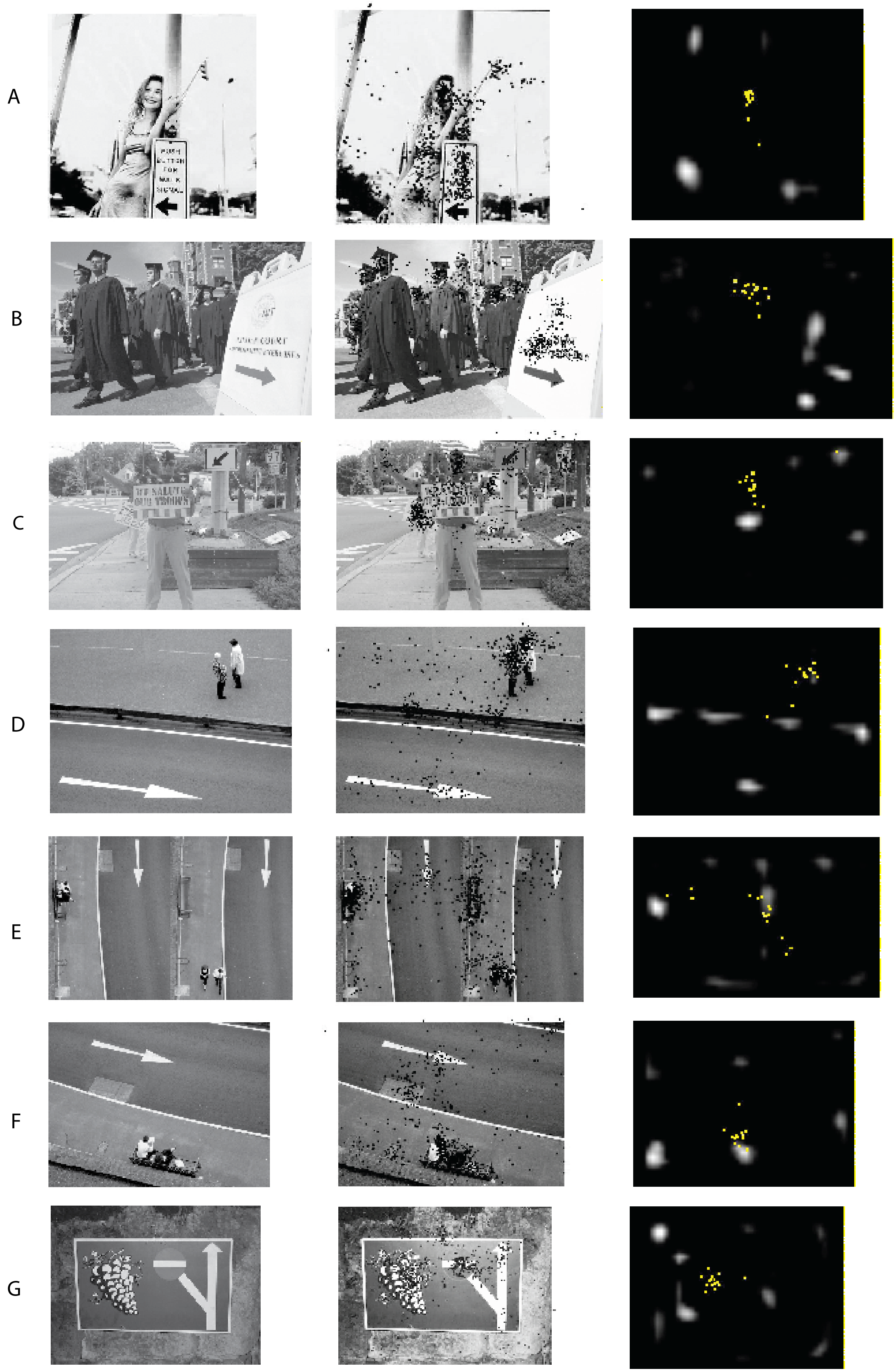

Figure 1.