

## Human social attention

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**Abstract:** The present chapter suggests that while there is strong evidence that specific brain systems are preferentially biased toward processing gaze information, this specificity is not mirrored by the behavioral data as measured in highly controlled impoverished model tasks. In less controlled tasks, however, such as when observers are left free to look at whatever they want in complex natural scenes, observers focus on people and their eyes. This agrees with one's intuition, and with the neural evidence, that eyes are special. We discuss the implications of these data, including that there is much to be gained by examining brain and behavioral processes to social stimuli as they occur in complex real-world settings.

**Keywords:** eye movements; social attention; gaze perception; attentional selection; cueing paradigm; scene perception; visual attention; saccades

Imagine you are riding your bicycle down the road, and you notice that there is a person standing on the sidewalk looking upward. Using this person's gaze direction, you turn your eyes to see what is being looked at. As this simple scenario illustrates, folk knowledge suggests that we are very interested in where other people are directing their attention, and that we use their eyes to infer where, and to what, they are attending. The intuition that we care about the attentional states of others has led to the birth of research in *social attention*. We have a strong intuition that eye gaze is a special social attention cue in that it tells us with a reasonable degree of reliability where someone is attending (Emery, 2000). As such, we would expect that (1) the

brain is particularly selective for eye gaze, and (2) humans readily use eye gaze to determine where others are directing their attention.

With regard to point (1), considerable research has been conducted on the neural mechanisms that are critical to processing gaze information, with much of this research suggesting that a key role is played by a region of cortex called the superior temporal sulcus (see Birmingham and Kingstone, 2009, for a review). It seems that one of the many functions of the superior temporal sulcus (STS), including biological motion processing, audiovisual integration, theory of mind, and face processing (see Allison et al., 2000; Hein and Knight, 2008, for reviews) is to process gaze direction. Single-cell studies with macaque monkeys have found populations of cells in the anterior STS that are selective for specific gaze directions (Perrett et al., 1985). Neuropsychological and lesion studies have found evidence for deficits in judging gaze direction associated with

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damage to the STS (e.g., Heywood et al., 1992; Akiyama et al., 2006). Some neuroimaging studies of human posterior STS activity have also found stronger activation for faces with averted gaze than for faces with direct gaze (e.g., Hoffman and Haxby, 2000), although in some cases the opposite effect was found (e.g., Pelphrey et al., 2004) or no significant difference between direct and averted gaze was found at all (e.g., Wicker et al., 1998; George et al., 2001; Calder et al., 2002). Most recently, researchers have looked at neural adaptation to demonstrate the presence of neurons in anterior STS that are finely tuned for processing left and right gaze directions (Calder et al., 2007).

The evidence for point (2), that humans use eye gaze to determine where others are directing their attention, is much more controversial and much of the present chapter focuses on this issue. We note that while there is evidence derived from laboratory-based attention-cuing studies (e.g., Posner, 1980) that people automatically shift their attention to where other people are looking (e.g., Friesen and Kingstone, 1998); recent research also indicates that people shift their attention automatically in response to a number of other familiar directional cues, most notably arrows (Eimer, 1997; Ristic et al., 2002; Tipples, 2002). Indeed, a number of the latest studies have been dedicated to determining whether the effects of gaze cuing are truly unique from the effects of arrow cuing, and whether gaze and arrow cuing arise from the same underlying neural system. We propose that while some differences do occasionally emerge between gaze and arrow cuing, their general convergence suggests that the cuing paradigm may be failing to capture many of the key aspects of eyes that distinguish them from other stimuli, like arrows. In other words, the general intuition that eyes are very special is correct, but the cuing paradigm is measuring eyes and arrows on a dimension that they share a great deal of similarity, i.e., their ability to communicate directional information (Gibson and Kingstone, 2006). The implication is that researchers may benefit by considering alternative approaches for studying the uniqueness of eyes relative to other stimuli.

At the conclusion of our chapter we present a new approach emphasizing the *selection* of gaze

information rather than the *orienting* of attention to where gaze is directed. To return to our initial example of a person on the sidewalk looking upward, our final section examines the selection of the person's gaze rather than subsequent orienting of attention to where that gaze is directed. When gaze information is examined in the laboratory in this way, the evidence indicates that people have a fundamental interest in eye information that far exceeds other information in the environment, including arrows. These data dovetail with the evidence that attentional selection is being driven by neural systems that give weight to the unique social information provided by the eyes of others, and hence they suggest a fruitful direction for future investigations.

### **The effect of gaze direction on spatial attention**

To get at this issue, researchers recently modified a model task popularized by Michael Posner (1980) and used it to investigate whether people are preferentially biased to attend to where someone else is looking. In the model cuing paradigm participants are presented with a central fixation dot that is flanked by two squares. The task is to make a key press as quickly as possible when a target item appears inside one of the squares. This target event is preceded by a cue, i.e., the flashing of one of the squares or the appearance of a central arrowhead pointing toward one of the squares. The standard finding is that the target is detected faster when it appears in the cued square than when it appears in the uncued square. Because the brain processes attended items more quickly than unattended items, it is concluded that target detection time is speeded because attention has been committed to the square that was cued.

It is noteworthy that there are two different ways that attention is manipulated in the cuing task. One way is to flash one of the squares. In this case, attention is directed to the cued square that flashed. This attention shift is considered exogenous (automatic) because people are faster to detect a target in the cued square even when the flashing does not predict where the target will

occur (i.e., the target appears in the cued location 50% of the time and in the uncued location 50% of the time). The other way to direct attention in this paradigm is to present a central arrowhead pointing left or right. In this case, attention is directed to the cued square that the arrowhead pointed toward. Since the early 1980s (Posner, 1980; Jonides, 1981) it has been assumed that this orienting happens only when the arrowhead predicts where the target will appear (e.g., the target appears in the cued location 80% of the time and in the uncued location 20% of the time). In other words, orienting to a central direction stimulus cue, like an arrow, does not occur when the cue is spatially nonpredictive. Thus, the attentional shift associated with a central directional cue is considered to be endogenous (voluntary).

Friesen and Kingstone (1998) hypothesized that given the intuition that eye gaze is a special social attention stimulus, perceived shifts in eye direction might automatically trigger attention shifts to gazed-at locations. This idea was tested by modifying the model-cuing task in two significant ways (Fig. 1). First, arrows pointing to the left and right were replaced by a schematic face that looked left or right. Second, the predictive value of the central cue was eliminated, i.e., eye direction did not predict where a target item would appear. Note that because the eyes were centrally located and spatially nonpredictive, the traditional line of thinking predicted that gaze would not lead to shifts of attention. In other

words, the assumption was that central directional cues should only produce a shift in attention if they reliably predict where a target is likely to appear. Remarkably, and contrary to traditional thought, spatially nonpredictive eye gaze triggered shifts of attention; target detection was faster for items at the gazed-at location than for items at the other location (see also, Langton and Bruce, 1999; Driver et al., 1999). This discovery led to the proposal that the attention shift to eye gaze was automatic because it emerged rapidly and occurred even when gaze direction did not reliably predict where a target would occur. And most importantly, it was thought that this effect was special to eyes, suggesting that the human brain may be specialized to shift attention automatically in response to where other people are attending/looking. The brain mechanisms for this “gaze cuing” effect were hypothesized to involve parietal cortex, which is involved in spatial orienting, and the STS, which is reciprocally connected with the parietal cortex (e.g., Harries and Perrett, 1991).

Thus, this gaze-cuing paradigm appeared to tap into social attention and the fundamental importance that humans place on the eyes of others. Furthermore, it suggested a “meeting of fields,” in that mainstream attention research methods could be used to study questions in the field of social cognition, and that social cognition could enrich our understanding of human attention.

This idea was soon tested by research examining whether other familiar directional cues, like

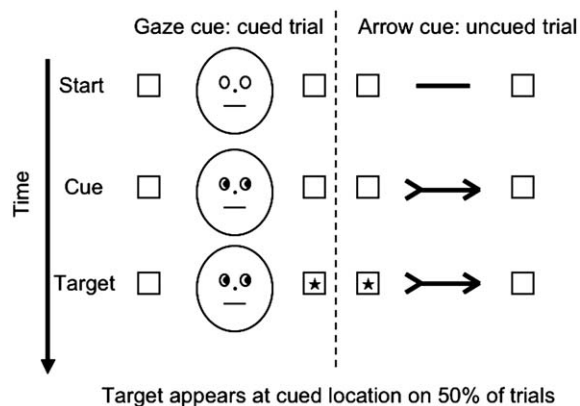


Fig. 1. The gaze-cuing paradigm (left) and the arrow-cuing paradigm (right).

arrows, would produce an automatic shift of attention to the cued location (Ristic et al., 2002; Tipples, 2002). It is very important to recall here that the endogenous (volitional) attention-cuing task that set the standard for all other cuing tasks that followed was founded on the principle that central arrow cues do not produce an orienting effect when they are spatially uninformative (Posner, 1980; Jonides, 1981). After all, if they did, then there would be little credibility to researcher's long-standing claim that informative central arrow cues tap into endogenous mechanisms (e.g., Posner, 1980; Jonides, 1981; Mueller and Rabbitt, 1989; Kingstone, 1992; Berger et al., 2005 to name but a small handful of what are literally hundreds of studies). It was therefore surprising when Ristic et al. (2002) and Tipples (2002) reported in separate investigations that central, spatially nonpredictive arrow cues, produce a robust reflexive orienting effect that is very similar to what is observed for gaze cues.

These findings raise the possibility that gaze cuing is not a unique or special effect. Understandably, this doubt has led to a flurry of research seeking to determine whether gaze cuing is different from arrow cuing, either at a behavioral or neural level. Below we review some of these studies.

One possibility is that while both gaze and arrows can orient attention automatically, and therefore both are important attentional cues, gaze cuing may be more strongly reflexive than arrow cuing, reflecting that eyes are biological stimuli with strong social meaning. In fact, there is some research that suggests a behavioral distinction between gaze and arrow cuing. Friesen et al. (2004) found that counterpredictive gaze cues, but not counterpredictive arrow cues, produced reflexive orienting to the cued location. This suggests that gaze cues are prioritized by the brain because of their social significance, leading to more reflexive shifts of attention than for arrow cues. Certainly, this is consistent with the findings that gaze direction is processed by a specialized neural system. Indeed, Downing et al. (2004) suggested that while almost any nonpredictive cue carrying spatial compatibility with the target will produce reflexive orienting, it is this more

complex influence of gaze cues, i.e., the resistance to top-down biases, that sets gaze cues apart from other directional cues. In support of this, Ristic et al. (2007) showed that while arrow cuing is sensitive to arbitrary cue-target color contingencies (i.e., it only occurs when the cue and target share the same color), gaze cuing is not, and therefore can be considered to be more reflexive than arrow cuing.

Further evidence comes from studies testing adults' *overt orienting* (involving eye movements) of attention in response to gaze cues. Ricciardelli et al. (2002) found different overt orienting signatures for central gaze cues and arrow cues. Subjects were asked to make a speeded saccade to the left or right of fixation, as indicated by a central square stimulus. In concert with studies of covert orienting to gaze direction, correct saccade latencies were faster on trials on which a face also gazed at the correct location, relative to when the face gazed at the incorrect location. The same effect occurred for a central arrow stimulus. However, only the *incongruent gaze* stimulus produced unwanted saccades toward the incorrect location; *incongruent arrows* failed in this respect. This is consistent with covert attention studies showing that orienting to gaze cues is more strongly reflexive than to arrow cues and persists despite instructions to orient elsewhere.

Finally, Ristic and Kingstone (2005) demonstrated the uniqueness of gaze cuing relative to a stimulus — not an arrow — that was physically identical to the gaze cue but could be perceived as the wheels on a car. They found that when an ambiguous stimulus was first perceived as eyes, it produced reflexive orienting, even in a later block in which subjects were told the stimulus could be perceived as a car. However, when the stimulus was first perceived as a car, it did not produce reflexive orienting. Reflexive orienting only occurred when subjects were later informed that it could be perceived as containing eyes. This suggests that the stimulus had to be perceived as having eyes before it could trigger orienting, and that once this percept was activated it triggered reflexive orienting even when an alternative percept was suggested. However, later results by

the same authors suggest limits to this finding, showing that an enlarged version of the ambiguous stimulus triggered orienting regardless of the percept that was adopted (Kingstone et al., 2004).

Despite the collection of research showing that gaze cuing may yield relatively subtle differences when compared to arrow cuing, other behavioral research has shown that gaze and arrow cues produce nearly identical shifts of attention (Hommel et al., 2001; Tipples, 2002). In contrast to Driver et al. (1999) and Friesen et al. (2004), Hommel et al. (2001) found that arrows *do* produce reflexive shifts in attention despite observers' knowledge that another location was more likely to receive the target. Similarly, Tipples (2008) replicated the conditions of Friesen et al.'s (2004) counterpredictive gaze cue study and reported reflexive orienting to the location cued by arrows and gaze even when a target was far more likely to appear elsewhere (like Friesen et al., this reflexive attention effect occurred concurrently with the volitional attention effect to the predicted target location). Furthermore, in contrast to Ricciardelli et al. (2002), Kuhn and Benson (2007) did not find different reflexive overt orienting signatures for gaze and arrow cues. The authors used a similar voluntary saccade paradigm to Ricciardelli et al., but used more traditional, "arrow-like", cues than did Ricciardelli et al. (who used simple arrowheads, e.g.,  $<$   $>$ ). Using these more effective arrow stimuli, the authors found that the interference effect for arrow cues was of equal magnitude to gaze cues. The only difference Kuhn and Benson found between the two types of cues was in the response latency for erroneous saccades, finding shorter error latencies for gaze cues than for arrow cues. However, a later study found no difference between errors elicited by arrows and gaze stimuli (Kuhn and Kingstone, 2009).

Because the behavioral research has generally failed to reveal robust differences between gaze and arrow cuing, one possibility is that these differences are only detectable by digging into the neural mechanisms underlying each type of cuing. Some neuropsychological studies suggest that there are different neural systems for gaze and arrow cuing (Kingstone et al., 2000; Ristic et al.,

2002; Akiyama et al., 2006). For instance, there is evidence from a study with split-brain patients that the reflexive gaze-cuing effect is lateralized to the hemisphere specialized for face processing (Kingstone et al., 2000). In contrast, in a later study this same split-brain patient showed no lateralization of reflexive orienting to nonpredictive arrows, with the cuing effect occurring in both hemispheres (Ristic et al., 2002). In addition, Akiyama et al. (2006) found that a patient with damage to her right superior temporal gyrus (STG) showed no orienting in response to gaze cues but preserved orienting to arrow cues. These findings are consistent with the idea that reflexive orienting to nonbiological cues is underpinned by subcortical brain mechanisms that are shared between the two hemispheres, whereas reflexive orienting to gaze cues is subserved by lateralized cortical mechanisms involved in face/gaze processing (e.g., Kingstone et al., 2004; Friesen and Kingstone, 2003).

However compelling these findings are, they must be interpreted with some caution. In particular, lesion studies which test very few individuals are difficult to interpret because of the natural variation in the gaze cuing effect across individuals. As Frischen et al. (2007) point out, some people do not show gaze cuing. Thus, in studies such as Akiyama et al. (2006), which tested only one participant, it is difficult to know whether the lesion interfered with gaze cuing or whether the patient never showed gaze cuing. Furthermore, it is important to consider the influence of low-level differences between gaze and arrow stimuli when interpreting results with single-patient case studies. For instance, the arrow cues in Akiyama et al.'s (2006) study may have conveyed direction more effectively than the gaze cues did, i.e., whereas the arrow cues had clear directionality, the gaze cues were only partially averted (off-center by 11%). A similar type of concern may be applied to the split-brain studies of Kingstone and colleagues (e.g., Kingstone et al., 2000; Ristic et al., 2002).

Neuroimaging studies with healthy populations have also been conducted in hopes shedding light on whether gaze cuing is unique in some way, with mixed results. For instance, there is evidence that

brain activation differences produced for gaze and arrow cuing may be partly due to the recruitment of different brain areas for visually analyzing gaze and arrow cues, and not necessarily for the subsequent shifts of attention (Hietanen et al., 2006). Once these basic visual processing differences are removed, and only the subsequent orienting of attention is examined, there is little evidence that gaze and arrow cues are subserved by distinct attentional mechanisms. Tipper et al. (2008) studied gaze and arrow cuing using an ambiguous stimulus that could be perceived as either an eye or an arrow, thus removing the physical stimulus differences normally present in comparisons of gaze and arrow cuing. Tipper et al. found very few differences between the neural activations underlying gaze and arrow cuing, save for a bigger sensory gain at the cued location for gaze cues than for arrow cues.

However, even these studies must be interpreted with caution, as both suffer from methodological limitations. For instance, the analysis of the Hietanen et al., 2006 study may have underestimated the unique contributions of social information. In particular, the analysis collapsed across valid and invalid trials, which is the critical comparison for the attention effect. And the relatively small number of participants in Tipper et al.'s (2008) fMRI experiment is a potential limitation given that the critical finding was a null difference in STG activity between gaze and arrow cuing.

As a final line of inquiry, Frischen et al. (2007) point out that if gaze and arrow cuing are subserved by separate neural systems, then one might expect that gaze- and arrow-cuing effects may not correlate strongly within an individual. Although little research has been committed to determining whether individuals who show strong gaze cuing also show strong arrow cuing, there is some evidence from studies of gender differences that suggests that gaze and arrow cuing are related. Bayliss et al. (2005) found that males show a weaker orienting effect for gaze cues than do females, consistent with previous findings that male infants make less eye contact than female infants (Lutchmaya et al., 2002) and therefore may be less sensitive to social cues. However, Bayliss et al. found the same gender difference for

arrow cuing, suggesting that gaze and arrow cuing are not distinct. That is, Bayliss et al.'s findings run counter to what would have been found if gaze and arrow cuing were unique: "If orienting to the direction of another person's eye gaze is functionally different to the symbolic cuing seen with arrows, for example, then no gender difference would be obtained with arrow cues: Males and females should display attention shifts of equivalent magnitude" (p. 642).

When taken together, the results are rather equivocal with regard to the uniqueness of gaze cuing. On the one hand, there are some studies that find subtle differences between gaze cuing and arrow cuing, but on the other hand, these differences often are not observed. Overall, the evidence that gaze cuing is unique from arrow cuing is weak.

What are the implications of this conclusion? Certainly, the finding that arrow cues produce nearly identical effects to gaze cues runs counter to one's intuition that eyes are unique, special social attention stimuli. However, it could be that arrows are also important social stimuli, which explains why they, too, produce reflexive shifts in attention. This potential status of arrows has not been overlooked. Kingstone et al. (2003) have written that "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). Thus, perhaps eyes and arrow produce identical effects on attention in the cuing paradigm because they are both important social cues.

An alternative explanation of the data is that the cuing paradigm may be failing to capture key aspects about eyes that distinguish them as special social stimuli that are unlike other stimuli, like arrows. In other words, the general intuition that eyes are special is correct, but the cuing paradigm may not be measuring what makes eyes distinct from arrows. Indeed, the cuing paradigm appears to be measuring eyes and arrows on a dimension that they share a great deal of similarity, i.e., their ability to communicate directional information (Gibson and Kingstone, 2006). This interpretation is supported by growing evidence that cuing effects similar to gaze cuing are found for a variety of

biological and nonbiological cues that convey direction. For instance, Downing et al. (2004, Experiment 1) found that a central face with its tongue pointing randomly left or right produced reflexive attention effects that were indistinguishable from gaze cuing effects. Hommel et al. (2001) found reflexive orienting both for non-predictive arrows and for nonpredictive directional words (e.g., “left,” “right”) presented centrally. Even more striking, Quadflieg et al. (2004) found equivalent cuing effects for drawings of averted eyes within human faces, within animal faces (e.g., tiger, owl), or within an apple or a gloved hand. The same cuing effect was found for a gloved hand containing two arrows instead of eyes. Thus, working from the basic intuition that eyes are very different social stimuli from arrows, one may conclude that the similarity found between eyes and arrows in the cuing paradigm tells us about the limitations of the cuing paradigm.

The results of this growing collection of studies suggest that *any* cue with a directional component, or more specifically, any cue carrying the potential for spatial compatibility with the target (e.g., arrow points left, target appears left) produces reflexive orienting of attention. From this perspective, behavioral differences found between cues could be reattributed to the differences in the cues’ ability to convey left/right information. 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 (2009) “Thus 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).

### **A new approach for studying social attention**

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. Rather than examining the orienting of attention in response to a cue (i.e., orienting *from* the cue to where the cue is pointing), we propose to study the selection of the cue itself (i.e., orienting *to* the cue). Consider a real world example of social attention: You are walking on campus toward your colleague when you notice that she is looking intensely at something on the ground. Using her gaze direction you orient your attention to see what she is looking at. Now, it is clear from this example that there are at least two distinct stages of social attention: first, you select (orient to) your colleague’s eyes as a key social stimulus, and second, you orient your attention from her eyes to select the location/object that she is looking at. Importantly, cuing studies with central symbolic cues are specifically designed to test only one of these attentional components: orienting from the cue. The initial *selection* of the cue is relatively trivial within the context of the cueing paradigm because the cue, that is, a gaze, arrow, word, or number stimulus, is presented at central fixation and typically in advance of the target object (Gibson and Kingstone, 2006). Thus, the experimenter essentially *preselects* the cue and places it at fixation (the current focus of attention). As we found in the preceding section, when there is effectively no selection process on the part of the observer, the prevailing literature indicates that eyes and arrows are generally given equal priority by the attention system. Does this general equivalence hold, however, when the observer’s *selection* of social cues is nontrivial and measured? In other words, will eyes and arrows be given equal priority when participants are provided with the opportunity to select them from a complex visual scene?

The fact that no studies have compared the selection of eyes versus arrows is noteworthy, given the strong tradition of research on selective attention (e.g., James, 1890; Broadbent, 1958, 1972; Moray, 1959; Treisman, 1960; Deutsch and Deutsch, 1963; Neisser, 1967). 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.

Now, before using measures of selection to compare the social relevance of eyes and arrows, one would want to verify that these measures tap into social attention mechanisms. Some of our own work has done just that. We have used the selection approach to demonstrate that observers select — by looking at — the eyes of people within complex scenes because they are interested in the social information provided by the eyes (Birmingham et al., 2008a, b). We presented real-world photographs of scenes with people and a variety of objects, and depicting a range of different natural social situations. The results of our work showed that indeed, observers do look mostly at the eyes of other individuals, and they look relatively infrequently at the rest of the scene (e.g., bodies, foreground objects, background objects). Importantly, we also found that this general interest in the eyes of others can be modulated by social factors. For instance, observers in our investigations selected the eyes more frequently in highly social scenes, such as scenes containing multiple people doing something together. They also selected the eyes more frequently when reporting on the social attention within the scenes relative to when completing other less socially focused tasks, such as describing the scenes (Birmingham et al., 2008b;

see also Smilek et al., 2006). These findings led us to conclude that our methodology captures some important social attention processes, revealing a preferential selection of gaze information that is enhanced by a social attention task and by the social content of the scene. This agrees also with our finding that the preferential selection of gaze cannot be explained by low-level saliency advantages conferred to eyes relative to the other items in the scenes (Birmingham et al., 2009, under review). Finally, it is noteworthy that our findings agree with the everyday intuition that eyes are unique social stimuli that are prioritized by the human attention system.

With the confidence that our basic approach taps into social attention, we adapted it in a recent study to determine whether observers select eyes and arrows to the same extent (Birmingham et al., 2009). We did this by presenting gaze and arrows within complex scenes and studying what people select to fixate. Scenes were shown for 15s during which observers simply looked at the images. A representative illustration of the data is shown in Fig. 2. What we found is that observers demonstrate a strong bias to fixate the eyes in the scene with few fixations committed to the arrows (Fig. 2A). Furthermore, while eyes and heads were likely to be prioritized, that is, looked at first, arrows were never fixated first. This general

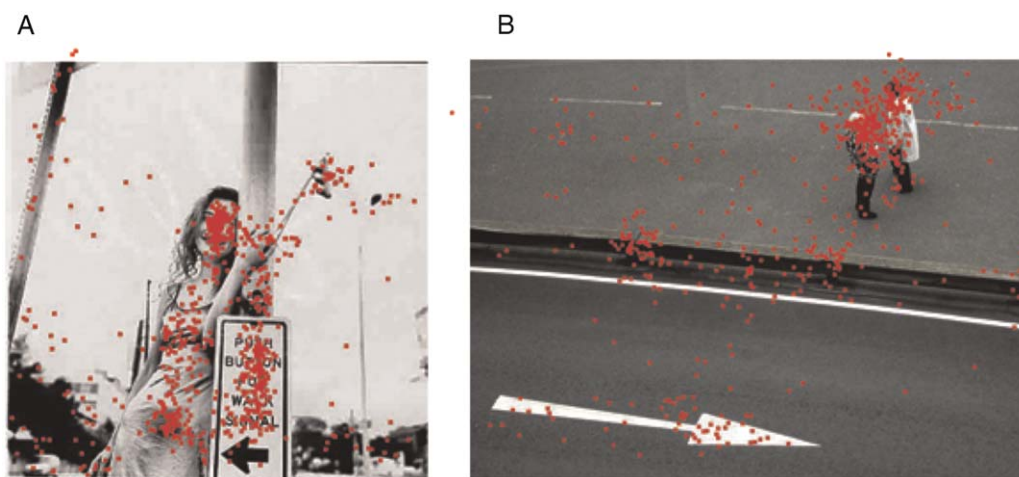


Fig. 2. Fixations (dots) overlaid on an image with eyes and arrows (A) and an image with larger arrows (B).



interest in people, and lack of interest in arrows, persists even when we make the arrow much larger than the people in the scene (Fig. 2B). Note also that these findings cannot be explained by low-level visual characteristics of the eyes or arrows, such as visual saliency (Itti and Koch, 2000), as we computed the saliency at fixated locations and found that it was no higher than what would be expected by chance. Overall, our data show that when one examines attentional selection, rather than orienting in response to a preselected centrally positioned stimulus (as in the cuing paradigm) what one finds is that people care about people, especially their eyes and faces. They rarely look at the arrows when they are small; and they rarely look at them when they are large. These findings indicate that in general, the human attention system does not treat eyes and arrows equivalently. When people are free to look at what they find important, they choose to look at people and their eyes. This profound and clear-cut difference between eyes and arrows has never been observed within the context of the cuing paradigm.

The implications of these preliminary data are both broad and deep. First, they suggest that when one takes a different approach to measuring the impact of eyes and arrows on the spatial attention system — one that moves away from the orienting of attention in response to a directional cue that the observer is forced to select (because it is presented at fixation in an otherwise uncluttered field), and moves toward the selection of items in a complex scene — then one finds that observers tend to select people and eyes rather than arrows.

Second, finding a profound difference between eyes and arrows would appear to lend support to the suggestion raised in the previous section, that the cuing paradigm may not be picking up on basic differences in the social relevance of eyes and arrows, differences that appear to be captured when selection is measured. This dovetails with the finding that when eyes and arrows are inserted as cues into the cuing paradigm, they tend to be treated the same way behaviorally (e.g., Tipples, 2008) and engage the same brain mechanisms (e.g., Tipper et al., 2008). The most reasonable explanation as to why this should be the case is

that the factor of interest in the cuing paradigm is cue/target location information, and eyes and arrows are well matched in their ability to deliver this type of information. On the other hand, the many features that make eyes and arrows different types of stimuli are not typically important to the cuing paradigm.

Third, the present data raise the possibility that when researchers place a face stimulus in isolation, as they do in the cuing paradigm, they may be bypassing a critical aspect of attention, i.e., the selection process. As we saw in the study mentioned above, the selection process allows one to assess the importance that observers place on different stimuli. When this selection opportunity is bypassed by the experimenter preselecting and presenting the stimulus to the observer in relative isolation, it is very difficult to gain a sense of the relative importance placed on each stimulus. Additionally, by preselecting and isolating different stimuli one may change the context in which the stimuli are normally embedded, and in doing so, change the meaning that is normally attached to those stimuli.

Fourth, the data and above considerations suggest that it would be wise to move from monitoring the eyes of observers while they view static *images* of people to monitoring the eyes of observers while they view moving images of people, and ultimately to studying how observers look at *real* people. To date virtually all of the research in social attention (including the data presented here) has been confined to situations involving static images of people. By definition, these images of people cannot attend to the observer while the observer is attending to them. This stands in sharp contrast to many situations in real life. Interestingly, while one might be tempted to predict that observers would look even *more* often at the eyes in real social situations than when they are presented with images of eyes, the opposite could just as easily be true. For instance, while eye contact is a functional part of everyday social interactions, social norms indicate that it is often rude to make excessive eye contact or to spend too much time looking at another person. Indeed, in some situations (e.g., being approached

by a hostile person) it may be appropriate to avoid eye contact altogether.

### Summary and future directions

The present chapter considered a body of behavioral evidence that sought to examine the functional impact of gaze direction on the spatial orienting of attention. Contrary to what had been expected from the neural evidence for a specialized system for processing gaze direction, these studies found that a range of cues — from eyes to arrows — have a similar effect on attentional orienting. In our second section we showed that when observers are left free to select what they want to attend to, they focus on people and their eyes — and not arrows — consistent with one's intuition and the neural evidence that eyes are special. We discussed a range of implications of this discovery, including that when researchers preselect a stimulus and simplify the setting it is normally embedded in, they may profoundly change the way a stimulus is processed relative to more complex real-world settings.

Thus, an exciting direction for future research is 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.

### Acknowledgment

This chapter is based on a substantially larger article by Birmingham and Kingstone (2009).

### References

- Akiyama, T., Kato, M., Muramatsu, T., Saito, F., Umeda, S., & Kashima, H. (2006). Gaze but not arrows: A dissociative impairment after right superior temporal gyrus damage. *Neuropsychologia*, *44*, 1804–1810.
- Allison, T., Puce, A., & McCarthy, G. (2000). Social perception from visual cues: Role of the STS region. *Trends in Cognitive Sciences*, *4*(7), 267–278.
- Bayliss, A. P., di Pellegrino, G., & Tipper, S. P. (2005). Sex differences in eye gaze and symbolic cueing of attention. *Quarterly Journal of Experimental Psychology A*, *58A*, 631–650.
- Berger, A., Henik, A., & Rafal, R. (2005). Competition between endogenous and exogenous orienting of visual attention. *Journal of Experimental Psychology General*, *134*, 207–221.
- 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.
- Birmingham, E., Bischof, W. F., & Kingstone, A. (2009). Get real! Resolving the debate about equivalent social stimuli. *Visual Cognition, Special issue, Eye guidance in natural scenes*, 1–21.
- Birmingham, E., Bischof, W. F., & Kingstone, A. (under review). Saliency does not account for fixations to eyes within social scenes. *Vision Research*.
- Birmingham, E., & Kingstone, A. (2009). Human social attention: A new look at past, present and future investigations. *The Year in Cognitive Neuroscience 2009: Annals of the New York Academy of Sciences*, *1156*, 118–140.
- Broadbent, D. E. (1958). *Perception and communication*. London: Pergamon Press.
- Broadbent, D. E. (1972). *Decision and stress*. New York: Academic Press.
- Calder, A. J., Beaver, J. D., Winston, J. S., Dolan, R. J., Jenkins, R., Eger, E., & Henson, R. N. A. (2007). Separate coding of different gaze directions in the superior temporal sulcus and inferior parietal lobule. *Current Biology*, *17*, 20–25.

- Calder, A. J., Lawrence, A. D., Keane, J., Scott, S. K., Owen, A. M., Christoffels, I., & Young, A. W. (2002). Reading the mind from eye gaze. *Neuropsychologia*, *40*, 1129–1138.
- Deutsch, J. A., & Deutsch, D. (1963). Attention: Some theoretical considerations. *Psychological Reviews*, *70*, 80–90.
- 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 reflexive visuospatial orienting. *Visual Cognition*, *6*, 509–540.
- 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.
- 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., & Kingstone, A. (2003). Covert and overt orienting to gaze direction and the effects of fixation offset. *NeuroReport*, *14*, 489–493.
- Friesen, C. K., Ristic, J., & Kingstone, A. (2004). Attentional effects of counterpredictive gaze and arrow cues. *Journal of Experimental Psychology: Human Perception and Performance*, *30*, 319–329.
- Frischen, A., Bayliss, A. P., & Tipper, S. P. (2007). Gaze cueing of attention: Visual attention, social cognition, and individual differences. *Psychological Bulletin*, *133*(4), 694–724.
- George, N., Driver, J., & Dolan, R. J. (2001). Seen gaze-direction modulates fusiform activity and its coupling with other brain areas during face processing. *Neuroimage*, *13*, 1102–1112.
- Gibson, B. S., & Kingstone, A. (2006). Visual attention and the semantics of space: Beyond central and peripheral cues. *Psychological Science*, *17*, 622–627.
- Harries, M. H., & Perrett, D. I. (1991). Visual processing of faces in temporal cortex: Physiological evidence for a modular organization and possible anatomical correlates. *Journal of Cognitive Neuroscience*, *3*, 9–24.
- Hein, G., & Knight, R. T. (2008). Superior temporal sulcus — It's my area: Or is it? *Journal of Cognitive Neuroscience*, *20*(12), 2125–2136.
- Heywood, C. A., Cowey, A., & Rolls, E. T. (1992). The role of the face cell area in the discrimination and recognition of faces by monkeys. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *335*, 31–38.
- 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.
- 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*. New York: H. Holt & Co.
- Jonides, J. (1981). Voluntary versus automatic control over the mind's eye's movement. In J. B. Long & A. D. Baddeley (Eds.), *Attention and performance* (Vol. IX, pp. 187–203). Hillsdale: Erlbaum.
- Kingstone, A. (1992). Combining expectancies. *The Quarterly Journal of Experimental Psychology Section A: Human Experimental Psychology*, *44*(1), 69–104.
- 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 Directory in Psychological Science*, *12*, 176–180.
- Kingstone, A., Tipper, C., Ristic, J., & Ngan, E. (2004). The eyes have it! An fMRI investigation. *Brain and Cognition*, *55*, 269–271.
- Kuhn, G., & Benson, V. (2007). The influence of eye-gaze and arrow pointing distractor cues on voluntary eye movements. *Attention, Perception & Psychophysics*, *69*(6), 966–971.
- Kuhn, G., & Kingstone, A. (2009). Look away! Eyes and arrows engage oculomotor responses automatically. *Attention, Perception & Psychophysics*, *71*, 314–327.
- 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.
- Lutchmaya, S., Baron-Cohen, S., & Raggatt, P. (2002). Foetal testosterone and eye contact in 12-month-old human infants. *Infant Behavior & Development*, *25*(3), 327–335.
- Moray, N. (1959). Attention in dichotic listening: Affective cues and the influence of instructions. *Quarterly Journal of Experimental Psychology*, *11*, 56–60.
- Mueller, H. J., & Rabbitt, P. M. A. (1989). Reflexive and voluntary orienting of visual attention: Time course of activation and resistance to interruption. *Journal of Experimental Psychology: Human Perception and Performance*, *15*(2), 315–330.
- Neisser, U. (1967). *Cognitive psychology*. New York: Appleton-Century-Crofts.
- Pelphrey, K. A., Viola, R. J., & 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., Smith, P. A. J., Potter, D. D., Mistlin, A. J., Head, A. S., Milner, A. D., & Jeeves, M. A. (1985). Visual cells in the temporal cortex sensitive to face view and gaze

- direction. *Proceedings of the Royal Society London. Series B, Biological Sciences*, 223, 293–317.
- Posner, M. I. (1980). Orienting of attention. *Quarterly Journal of Experimental Psychology*, 32, 3–25.
- Quaddlieg, S., Mason, M. F., & Macrae, C. N. (2004). The owl and the pussycat: Gaze cues and visuospatial orienting. *Psychonomic Bulletin & Review*, 11(5), 826–831.
- 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., & Kingstone, A. (2005). Taking control of reflexive social attention. *Cognition*, 94, B55–B65.
- Ristic, J., Wright, A., & Kingstone, A. (2007). Attentional control and reflexive orienting to gaze and arrow cues. *Psychonomic Bulletin & Review*, 14(5), 964–969.
- Smilek, D., Birmingham, E., Cameron, D., Bischof, W. F., & Kingstone, A. (2006). Cognitive ethology and exploring attention in real world scenes. *Brain Research*, 1080, 101–119.
- Tipper, C. M., Handy, T. C., 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 uninformative arrows. *Psychonomic Bulletin & Review*, 9, 314–318.
- Tipples, J. (2008). Orienting to counterpredictive gaze and arrow cues. *Attention, Perception & Psychophysics*, 70, 77–87.
- Treisman, A. M. (1960). Contextual cues in selective listening. *Quarterly Journal of Experimental Psychology*, 12, 242–248.
- Wicker, B., Michel, F., Henaff, M. A., & Decety, J. (1998). Brain regions involved in the perception of gaze: A PET study. *Neuroimage*, 8, 221–227.