Nonattentional effects of nonpredictive central cues

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Recent evidence suggests that nonpredictive gaze, hand, arrow, and peripheral cues elicit shifts of reflexive attention. In the present article, we address whether these cues also influence the decision criterion in a go/no-go task. Nonpredictive central gaze and hand cues pointed toward or away from the location of an imminent target. Responses to the targets were faster, and false alarm errors were more frequent, when cues pointed toward the target than when they were directed away from it. Although a similar pattern was observed with nonpredictive arrow cues, it was not seen with nonpredictive peripheral cues. These results suggest that nonpredictive central cues not only affect attention, but also bias decision processes.

Since the early work of Posner (1980), it has been argued that predictive central cues evoke a shift of voluntary, *endogenous* attention. These central cues predict, with some degree of certainty, the location of the imminent target. The effects of predictive central cues are vulnerable to concurrent memory load (Jonides, 1981). It is thought that shifts of endogenous attention, elicited from predictive central cues, improve target processing by excluding external noise (Lu & Doshier, 2000), although others have argued that predictive central cues also enhance the perceptual representation of the target (Prinzmetal, McCool, & Park, 2005). Shifts of reflexive, *exogenous* attention, however, are elicited from nonpredictive peripheral cues. The effects of peripheral cues are impervious to concurrent memory load and instructions to ignore the cue (Jonides, 1981). Like endogenous attention, exogenous attention improves target processing by excluding external noise from the target (Doshier & Lu, 2000). Unlike endogenous attention, however, exogenous attention also enhances the perceptual representation of the target (Doshier & Lu, 2000). There are other differences between exogenous and endogenous forms of orienting. Endogenous attention increases the Stroop effect, whereas exogenous attention decreases it (Funes, Lupiáñez, & Milliken, 2007). Exogenous orienting effects are greater within a conjunction task than within a feature task, whereas endogenous orienting effects are similar in both tasks (Briand & Klein, 1987). Although endogenous and exogenous attention facilitate responding to impending targets, the mechanisms by which they do so are likely different (Klein, 1994; Klein & Shore, 2000).

Klein and colleagues have uncovered another important dissociation between endogenous and exogenous attention. Whereas endogenous attentional effects interact with nonspatial stimulus–response probability effects (Handy, Green, Klein, & Mangun, 2001; Kingstone, 1992; Klein

& Hansen, 1990), exogenous attentional effects do not (Klein, 1994). The effects of endogenous cues on response times (RTs) are larger for high-frequency targets than they are for less frequent targets. Moreover, the difference in error rates between the infrequent and frequent targets is greater at the cued location than it is at the uncued location. In other words, when presented at the cued location, less frequent targets are more likely to be classified incorrectly than frequent targets. Handy et al. referred to this pattern of results as *postspotlight masking*, implying that late pigeonholing effects (e.g., Broadbent, 1971) mask the effect of endogenous orienting to low-frequency targets. Accordingly, Klein (1994) argued that predictive central cues, but not nonpredictive peripheral cues, influence the decision criterion.

Nonpredictive peripheral cues have early (attentional facilitation) and late (i.e., inhibition of return, or IOR) effects on information processing. Posner and Cohen (1984) discovered a biphasic response from nonpredictive peripheral cues: Responses to cued targets are initially facilitated by a cue; but with an extended (greater than 300 msec) cue–target onset asynchrony (CTOA), responses to cued targets become slower than those to uncued targets. Posner and colleagues (Posner, Rafal, Choate, & Vaughan, 1985) named this phenomenon *inhibition of return* because it was thought that attention is inhibited from returning to a previously inspected location (see Klein, 2000, for a review). However, there is growing evidence for a nonattentional component to IOR as well (Ivanoff & Klein, 2001, 2004, 2006; Ivanoff, Klein, & Lupiáñez, 2002; Ivanoff & Taylor, 2006; Klein & Taylor, 1994; Pratt, Adam, & O'Donnell, 2005; Taylor, 2007; Taylor & Ivanoff, 2003). Ivanoff and Klein (2001) first noted that IOR is characterized by *faster* responses, and *more* false alarms (FAs), to uncued targets than to cued targets. In their task, “go” targets instructed participants to make a response, whereas

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“no-go” targets instructed them to withhold responding. This pattern (i.e., slower RTs and fewer FAs for cued targets) is what one might expect if IOR biases responding away from the cued location by raising the decision criterion. Raising the criterion at the cued location causes more time to elapse, allowing more evidence to accrue for target decisions (Klein & Taylor, 1994). Because go trials are more frequent than no-go trials in these types of experiments, this pattern is highly reminiscent of the interaction between target frequency and endogenous orienting that was observed by Klein and colleagues (see Ivanoff & Klein, 2004, for a recent discussion of these findings). These results do not suggest that IOR influences only the decision criterion. Rather, they suggest only that *one* of the effects of IOR is on the decision criterion. Taken together, the evidence from the literature suggests that IOR and endogenous attention affect the decision criterion, but exogenous attention does not (see Prinzmetal et al., 2005, for an alternative interpretation of exogenous-orienting effects).

Nonpredictive Symbolic Central Cues

Numerous studies have demonstrated that the direction of another's gaze, even the gaze of a line-drawing figure, can speed detection responses to impending targets (Bayliss, di Pellegrino, & Tipper, 2005; Bayliss & Tipper, 2006a; Friesen & Kingstone, 1998, 2003; Friesen, Moore, & Kingstone, 2005; Friesen, Ristic, & Kingstone, 2004; Frischen, Bayliss, & Tipper, 2007; Kingstone, Tipper, Ristic, & Ngan, 2004; Langton & Bruce, 1999, 2000; Ristic, Friesen, & Kingstone, 2002; Ristic & Kingstone, 2005). Although gaze cues are presented centrally, the fact that they are nonpredictive implicates a role for exogenous attention. The literature generally supports a similarity between the kind of attention that is elicited from nonpredictive gaze and the kind that is elicited from peripheral cues. Peripheral cues (Klein, 2000; Posner & Cohen, 1984) and gaze cues (Frischen, Smilek, Eastwood, & Tipper, 2007; Frischen & Tipper, 2004) produce IOR with long CTOAs, although the precise time course of IOR differs between them. Peripheral and gaze cues seem to elicit reflexive shifts of attention, even when the cue is counterpredictive (Driver et al., 1999; Friesen et al., 2004; McCormick, 1997). Although gaze cues are central, the extant literature has generally suggested that they induce exogenous shifts of attention.

Other studies have demonstrated that nonpredictive central arrow cues facilitate target detection (Hommel, Pratt, Colzato, & Godijn, 2001; Ristic et al., 2002; Ristic & Kingstone, 2006; Tipples, 2002) and produce IOR (Taylor & Klein, 2000). These discoveries were surprising, given that earlier research (Jonides, 1981) had failed to find any effect of nonpredictive central cues on target detection. The results of a recent study (Gibson & Bryant, 2005), however, suggest that Jonides's null finding may have been the result of a short cue duration (25 msec) coupled with a short CTOA (50 msec). The short CTOA may not have been sufficient for a complete visual analysis of the arrow cue and the subsequent shift of attention. Gibson and Bryant demonstrated that nonpredictive central arrow cues do have attentional effects with 50-msec

CTOAs if early CTOA conditions are randomly intermixed with longer cue durations and longer CTOAs, suggesting that top-down factors influence orienting from nonpredictive central arrow cues.

Although gaze and arrow cues do seem to facilitate detection responses, the similarities may end there. Arrow cues do not seem to recruit attentional resources in precisely the same way that gaze cues do (Bayliss et al., 2005; Friesen et al., 2004; Ristic et al., 2002; but see Tipples, 2008). IOR has been demonstrated to appear with arrow cues with a CTOA of 1 sec (Taylor & Klein, 2000), but IOR from gaze cues does not appear until ~2.4 sec (Frischen & Tipper, 2004). Moreover, Friesen et al. (2004) observed facilitation from gaze and an expectancy simultaneously. Even so, the orienting effects from arrow cues were ineffective when they were combined with the spatial expectancy. Individual differences in voluntary control may contribute to the relative ineffectiveness of arrow cues, however (Tipples, 2008). Although gaze and arrow cues trigger reflexive shifts of attention, gaze cues may do so more strongly (Tipper, Handy, Giesbrecht, & Kingstone, 2008).

Many studies of nonpredictive central (gaze and arrow) cues have used a detection task with catch trials. A catch trial is typically one in which the cue is presented but the target is not. These catch trials can be used to ensure that responding is based on the detection of the target and is not anticipatory. Although catch trials effectively reduce the frequency of premature responding, they are ineffective as a measure of response accuracy, because catch-trial errors cannot be separated according to cuing conditions (i.e., cued and uncued) when there is no target. In studies that have reported accuracy in discrimination tasks, gaze cues had no effect on accuracy (e.g., Bayliss, Paul, Cannon, & Tipper, 2006), or they resulted in fewer errors on cued trials (e.g., Bayliss & Tipper, 2006b). That nonpredictive central gaze cues and predictive symbolic cues similarly affect N1 and P1 event-related potential (ERP) components suggests that gaze cues improve visual-information processing (Schuller & Rossion, 2001). These findings do not preclude the possibility that nonpredictive central cues have other effects on information processing as well.

Although speeded target detection from gaze cues may result from reflexive orienting, reflexive attention is not the only process that speeds target detection. Here we assess whether central gaze and arrow cues induce a response bias that is akin to that induced by IOR and endogenous attention. We used a go/no-go task, similar to that used by Ivanoff and Klein (2001, 2004) in their investigations of IOR, to measure RTs and FAs (i.e., erroneous responses to no-go targets) to both cued and uncued targets. We assessed the effects of central, nonpredictive gaze (Experiment 1), hand (Experiment 2), arrow (Experiment 3), and peripheral cues (Experiment 4) on response decisions.

EXPERIMENT 1

The aim of the present experiment was to determine whether gaze cues bias responding toward the cued (i.e., gazed-at) side. On each trial, a central stick figure looked to the left or to the right. The gaze of the cartoon fig-

ure did not predict the target's location. Most of the time (75%), the target was a black square, signaling that a response should be executed. The remaining trials were no-go trials (using a checkerboard stimulus), signaling that a response should be withheld. A higher ratio of go trials to no-go trials creates an expectancy for go targets: Less stimulus-based evidence is necessary to make the decision that a go target is present, perhaps because of early preparation for the likely stimulus–response ensemble (Low & Miller, 1999). Responses are thus faster to go targets, and there are frequent FAs to no-go targets. Likewise, if gaze cues lower the decision criterion at the cued (i.e., gazed-at) location, then less target evidence will be required at the cued than at the uncued location. When gaze cues are combined with the expectancy for go targets, moreover, responding should be faster, and FAs more frequent, for targets that are presented at the cued location.

Method

Participants. Twenty volunteers participated in a 45-min session for course credit or pay (\$5). All participants had normal or corrected-to-normal vision. Each volunteer signed an informed consent document, approved by the local research ethics committee, before participating in the experiment.

Apparatus and Stimuli. An iMAC running Superlab (Cedrus, San Pedro, CA) was used to present stimuli, and a standard keyboard was used to collect responses. Participants sat approximately 57 cm from the display. The fixation display was an image of a stick figure. The middle portion of the stick figure had a fixation point that was 0.6° in diameter. This fixation point intersected the figure's arms and trunk. The distance from the fixation point to the head of the figure was 1.0°. The head was a perfect circle that was 2.1° in diameter. The eyes were two smaller circles that were 0.7° in diameter and were po-

sitioned 0.5° apart from each other. Within the eyes was a 0.4° black dot, which served as the pupil. The cue was the same image as the fixation display, except that the pupils of the stick figure shifted so that it appeared to be looking left or right (see the top left of Figure 1 for a graphical depiction of the cue). The targets were presented 6.2° to the left or the right of the center of the stick figure, and they were placed vertically midway between the eyes and the hands of the stick figure. Go targets were black squares that were 1.5° on each side. No-go targets were black-and-white checkerboards, also 1.5° on each side.

Design. In the cued condition, the stick figure looked at the impending target. In the uncued condition, it looked away from the target. There were two CTOAs: 100 msec and 600 msec. In each block, the gaze of the stick figure pointed randomly to the left or to the right. The targets (go and no-go) were also presented randomly to the left or right of the stick figure. Go targets were more frequent than were no-go targets, appearing on 75% of the trials. There were nine blocks of 64 trials. In total, there were 108 go trials (2×2) and 36 no-go trials per cell. Participants were instructed to respond by pressing the "n" key whenever a go target was presented. Participants were informed that the cues were uninformative and that the go trials would be more frequent than the no-go trials. They were also instructed to maintain fixation on the central dot for the duration of the trial.

Procedure. Each trial began with the presentation of the stick figure looking straight ahead for 1,200 msec. Subsequently, the gaze of the figure averted to the left or to the right. After a CTOA of 100 msec or 600 msec, a go or no-go target appeared. The go target remained on the screen until a response was made. The no-go target remained present for 1,500 msec or until an FA was made.

Results and Discussion

Responses that were greater than 900 msec were excluded from further analyses. This criterion eliminated less than 1% of all trials. FA rates and the mean of individual participants' median RTs are presented in Table 1.

Figure 1. Cuing effects (uncued – cued difference) for Experiments 1–4. At the top are graphic illustrations of leftward cues. These cues are not drawn to scale. Error bars are 95% confidence intervals. RT, reaction time; FAs, false alarms.

Table 1
Mean Reaction Time (RT) and Mean Percentage of False Alarms (FAs) for
Each Cue Type, CTOA, and Cuing Condition in Experiments 1–4

Experiment	Cue Type	CTOA	Cued		Uncued		Uncued – Cued	
			RT (msec)	Mean % of FAs	RT (msec)	Mean % of FAs	RT (msec)	Mean % of FAs
1	Gaze	100	350	12.4	355	8.5	+5	–3.9
		600	329	10.8	336	10.0	+7	–0.8
2	Hand	100	342	12.8	354	10.7	+12	–2.1
		600	316	12.6	334	10.1	+18	–2.5
3	Arrow	100	368	6.9	382	6.3	+14	–0.6
		600	345	8.1	365	6.1	+20	–2.0
4	Peripheral	100	376	4.9	411	4.2	+35	–0.7
		600	338	7.0	357	8.2	+19	+1.2

Note—CTOA, cue–target onset asynchrony.

The left side of Figure 1 illustrates the overall cuing effect (uncued – cued) for RTs and FAs.

Median RTs were entered into a 2 (cuing: cued targets and uncued targets) $\times$ 2 (CTOA: 100 msec and 600 msec) ANOVA. There was a main effect of cuing [$F(1,19) = 16.17, p = .0007$, power = .979] owing to a 6-msec advantage for cued targets, and a main effect of CTOA [$F(1,19) = 114.29, p < .0001$, power > .999] owing to faster responses to targets with the longer CTOA. The interaction was not significant [$F(1,19) = 0.088, p = .770$, power = .059].

FAs (i.e., responding to no-go targets) were entered into the same ANOVA that was used in the analysis of RTs. Only the main effect of cuing was significant [$F(1,19) = 5.08, p = .036$, power = .565], with more FAs to cued targets than to uncued targets.

As in other studies of gaze cuing, we observed faster responding to targets at the cued (gazed-at) location than to targets at the uncued location. Unlike other studies, however, our results also demonstrated that gaze cues increase FAs to the cued location. This kind of speed–accuracy trade-off is reminiscent of that observed with IOR (see, e.g., Ivanoff & Klein, 2001), in which uncued trials are faster—and produce more FAs—than do cued trials. The finding that there were faster responses and more FAs at the gazed-at location supports the notion that gaze cues bias responding by shifting the decision criteria. These results do not argue against an attentional interpretation of gaze cuing, naturally, but they do implicate an effect of gaze cues on information processing beyond spatial attention.

EXPERIMENT 2

In Experiment 2, we assessed whether the converse effects of cuing on RTs and FAs extend to other forms of social cues. Langton and colleagues have shown that manual pointing gestures speed responding to target stimuli at congruent (i.e., cued) locations (Langton & Bruce, 2000; Langton, Watt, & Bruce, 2000). Here we assess whether manual cues bias responding in the same manner as do gaze cues.

Method

Participants. Twenty-two volunteers participated in a 45-min session for course credit or pay (\$5). All participants had normal or

corrected-to-normal vision. None of the volunteers had participated in Experiment 1.

Apparatus, Stimuli, Design, and Procedure. The methodology was the same as that in Experiment 1, with two exceptions. First, the pupils of the stick figure were removed. Second, the hands of the stick figure were modified to include fingers. During the fixation interval (1,200 msec), the lower fingers were rolled into a partial fist, with the index finger pointing toward the observer. This was accomplished by inserting one circle at the top (0.3°) of the hand and creating three horizontal ovals (of equal height) to fill the rest of the hand. The manual-pointing cue is illustrated in Figure 1. Both hands pointed either to the left or to the right. The index finger of the stick figure extended 0.7° to the left or the right. The knuckles of the other fingers also extended slightly to the left or the right when the cue hand became the cue.

Results and Discussion

RTs were excluded, as was described in Experiment 1. The exclusion criteria eliminated less than 1% of all trials. One participant was removed from the analysis for having an exceptionally high FA rate (57%). The median RTs of the remaining 21 participants were entered into a 2 (cuing) $\times$ 2 (CTOA) repeated measures ANOVA. Only the main effects of cuing [$F(1,20) = 76.25, p < .0001$, power > .999] and CTOA [$F(1,20) = 67.19, p < .0001$, power > .999] were significant. Cued RTs were 15 msec faster than uncued RTs, and responses at the long CTOA were faster than responses at the short CTOA. FAs were entered into the same ANOVA that was used with median RTs. Only the cuing main effect was significant [$F(1,20) = 5.44, p = .030$, power = .598], because there were 2.3% more FAs on cued trials than on uncued trials. Like gaze cues, the hand cues facilitated response speed at the cost of increasing FAs. This finding is consistent with an effect of manual-pointing cues on the decision criterion.

EXPERIMENT 3

Although the hand cues that were used in Experiment 2 are a kind of social cue, they are visually and conceptually similar to symbolic, nonsocial directional cues (i.e., arrows) in that they point to something. In Experiment 3, we examined whether the effect of nonpredictive central cues on the FA rate is unique to social cues. Many studies have found that nonpredictive arrows, like nonpredictive gaze, affect responding to subsequent targets (Bayliss et al., 2005; Ristic et al., 2002; Ristic & Kingstone, 2006;

Taylor & Klein, 2000; Tipples, 2002). In the present experiment we assessed whether symbolic arrow cues affect FAs in a go/no-go task.

Method

Participants. Twenty-seven volunteers participated in a 45-min session for course credit or pay (\$5). All participants had normal or corrected-to-normal vision, and none of them had participated in the previous experiments.

Apparatus, Stimuli, Design, and Procedure. The methodology was the same as that used in previous experiments, with the following exceptions. The stick figure was never presented. A trial began with the presentation of the central fixation point and two empty placeholders for 1,200 msec. The placeholders were horizontally aligned with the fixation point and were placed 6.2° from fixation. The placeholder boxes were 2.1° on each side. The arrow cue is illustrated in Figure 1. The long arm of the arrow was 2.7°, and it was on the same side of space that it pointed to. The short arm (2.1°) was on the opposite side of space.

Results and Discussion

The exclusion criteria eliminated less than 1% of all trials. Median RTs were entered into the same ANOVAs, and with the same factors (cuing and CTOA), as those that were used in previous experiments. The 16-msec advantage for cued targets was significant [$F(1,26) = 24.49$, $p < .0001$, power = .999]. The main effect of CTOA [$F(1,26) = 21.22$, $p < .0001$, power = .997] resulted from a 20-msec advantage for responses at the long CTOA. The interaction was nonsignificant [$F(1,26) = 2.32$, $p = .14$, power = .296].

The analysis of FAs revealed a nonsignificant main effect of cuing [$F(1,26) = 1.78$, $p = .19$, power = .238] and of CTOA [$F(1,26) = 0.40$, $p = .534$, power = .091] and a nonsignificant interaction between CTOA and cuing [$F(1,26) = 1.01$, $p = .32$, power = .155]. Unlike social cues, arrow cues did not seem to have a significant effect on the frequency of FAs; however, the numerical direction of the FA cuing effect was consistent with a criterion shift. We address this nonsignificant effect more fully in the General Discussion section.

EXPERIMENT 4

In Experiment 4, we assessed whether social cues and peripheral cues similarly affect RTs and FAs. There is ample evidence that IOR affects FAs (Ivanoff & Klein, 2001, 2003, 2004, 2006; Ivanoff & Taylor, 2006; Taylor, 2007; Taylor & Ivanoff, 2003), but only one study that we know of has examined the effect of RTs and FAs in an asymmetric go/no-go task (i.e., a task with a greater ratio of go trials to no-go trials) with CTOAs that are short enough to measure attentional facilitation (Ivanoff & Klein, 2003). When conditions provide the opportunity for peripheral cues to facilitate RTs, cuing does not significantly affect FAs (Ivanoff & Klein, 2003). Accordingly, we do not expect peripheral cues to affect the FA rate. The goal of the present experiment was to determine whether nonpredictive peripheral cues affect FAs. Unlike in Ivanoff and Klein (2003), however, the cue remained present with the target. This procedure matched that of

Experiments 1–3, and that of much of the literature on gaze cuing.

Method

Participants. Twenty-one students volunteered in a 45-min session for course credit or pay (\$5). All participants had normal or corrected-to-normal vision.

Apparatus, Stimuli, Design, and Procedure. The methodology was similar to that used in previous experiments, with one important difference: The cue was the thickening (from 1 pixel to 5 pixels) of the left or right placeholder. As in the previous experiments, the cue remained visible when the target appeared.

Results and Discussion

RTs were trimmed in the same manner as that used in previous experiments, eliminating less than 1% of all trials. The 2 (cuing) $\times$ 2 (CTOA) ANOVA of median RTs revealed main effects of cuing [$F(1,20) = 45.28$, $p < .0001$, power > .999] and of CTOA [$F(1,20) = 119.61$, $p < .0001$, power > .999], and a significant interaction between these two factors [$F(1,20) = 9.96$, $p = .005$, power > .866]. The facilitative effect of the cue was greater at the short CTOA (uncued mean RT – cued mean RT = 35 msec) than it was at the long CTOA (19 msec). Although one might expect IOR with CTOAs greater than 300 msec (Ivanoff & Klein, 2001, 2004; Posner & Cohen, 1984), the absence of IOR here was not that surprising. Unlike cues in other cuing studies, the cue in the present experiment remained visible during the presentation of the target. This methodological feature is common practice in the gaze-cuing literature (see, e.g., Downing, Dodds, & Bray, 2004; Driver et al., 1999; Friesen et al., 2004), but to our knowledge it has never been used to explore IOR. Observing IOR in cuing tasks seems to require the removal of attention from the cued location (Briand, Larrison, & Sereno, 2000; MacPherson, Klein, & Moore, 2003; Pratt & Fischer, 2002; Prime, Visser, & Ward, 2006); thus, we likely failed to observe IOR with the long CTOA because the persistence of the cue held attention until the target was presented. The significant reduction of the facilitative effect of the cue by 600 msec in the present experiment, however, may be the result of a diminishing attentional effect and/or an increasing IOR effect (Berlucchi, Chelazzi, & Tassinari, 2000; Klein, 2000; Lupiáñez et al., 2004).

The analysis of FAs revealed a significant effect of CTOA [$F(1,20) = 9.28$, $p = .006$, power = .839], with 3.0% more FAs at the long CTOA than at the short CTOA. More importantly, the main effect of cuing was not significant [$F(1,20) = 0.06$, $p = .809$, power = .056]. Although the difference was nonsignificant, FAs were numerically more frequent to no-go targets at the uncued location than they were at the cued location (Figure 1). This pattern of results is not consistent with an effect on the decision criterion.

GENERAL DISCUSSION

We investigated whether nonpredictive central and peripheral cues bias responding in a go/no-go task. Previous investigations have repeatedly demonstrated cuing effects

from nonpredictive gaze, arrow, and peripheral cues in simple detection and discrimination tasks. The present study extends this previous work, in that we have observed these cuing effects in a go/no-go task. More importantly, we demonstrated that the facilitative effect of nonpredictive social cues (i.e., gaze and hand pointing) is implemented, at least in part, as a response bias. Not only were responses faster to cued targets than they were to uncued targets, but there were more FAs to the cued targets as well. This pattern is consistent with the proposal that nonpredictive central social cues lower the decision criterion at the cued location. Critically, that this pattern of results was not observed with peripheral cues suggests that peripheral cues do not bias responding. We have thus demonstrated a behavioral dissociation between nonpredictive central and peripheral cues by measuring the FA rate.

Peripheral Cues

It is worth noting that we did not find any effect of nonpredictive peripheral cues on the FA rate. This is consistent with previous work that also failed to find an effect of exogenous attention on the FA rate (Ivanoff & Klein, 2003). It is also consistent with past research that has failed to find an effect of exogenous attention on target-identification accuracy (Prinzmetal et al., 2005). According to Prinzmetal et al. (2005), nonpredictive peripheral cues affect only decision processes (*channel selection*). They argue that peripheral cues create a kind of decision confusion when the target appears at a different location (e.g., see Hawkins et al., 1990). Responding to uncued targets is slowed because the cue and the target appear in different locations, creating a form of decision conflict between the representation of the cue and the target. This channel-selection process does not affect the perceptual representation of the target, and should therefore not affect target-identification accuracy. On cued trials, the cue and target appear in similar locations, so there is no location uncertainty, and responding is fast. Our finding that peripheral cues do not affect FAs can be construed as consistent with this view; however, Prinzmetal et al. (2005, p. 89) also argued that channel-selection (i.e., facilitation from peripheral cues) and criterion-shift (i.e., IOR from peripheral cues; cf. Klein & Taylor, 1994) mechanisms are similar. Our results here (Experiment 4) and elsewhere (e.g., Ivanoff & Klein, 2001) suggest that the late (IOR) and early (exogenous attention) effects of peripheral cues do not have identical effects on target processing: Only IOR affects the FA rate. Prinzmetal, Leonhardt, and Garrett (2008) recently argued, moreover, that gaze cues and peripheral cues have indistinguishable effects on information processing. Our results demonstrate that the facilitative effects from nonpredictive peripheral (Experiment 4) and social (Experiment 1 and 2) cues are clearly not identical: Only central social cues have an impact on the FA rate.

Arrow Cues

Unfortunately, the FA cuing effects from Experiment 3 (arrow cues) were not as simple to interpret as those from the other experiments. Although it may be tempting to de-

scribe the null effect as a nil effect, further analyses suggest that this interpretation would be misleading. First, a comparison of the magnitude of the FA cuing effects across experiments suggests that the effect of arrow cues on FA rates is simply weak. As is evident from Figure 1, the FA cuing effects from gaze and manual cues (Experiments 1 and 2) did not differ significantly from one another [$F(1,39) = 0.001, p = .975, \text{power} = .05$]. To simplify the reporting of further analyses, we combined the FA rates from gaze and arrow cues (i.e., the social cues). The FA cuing effects from social and arrow cues did not significantly differ. A $2 (\text{cuing}) \times 2 (\text{CTOA}) \times 2 (\text{cue type: social, arrow})$ ANOVA on the FA rates revealed a strong main effect of cuing [$F(1,66) = 9.451, p = .003, \text{power} = .875$] and a nonsignificant interaction between cuing and cue type [$F(1,66) = 0.700, p = .406, \text{power} = .125$]. When the FA rates for arrow cues and peripheral cues were analyzed together, again with cue type (arrow cues vs. peripheral cues) as a between-subjects factor, however, the main effect of cuing was not significant [$F(1,46) = 0.525, p = .473, \text{power} = .106$], and neither was the cue type $\times$ cuing interaction [$F(1,46) = 1.17, p = .285, \text{power} = .175$]; however, an ANOVA with social cues and peripheral cues revealed a significantly greater FA cuing effect for the social cues than for the peripheral cues [$F(1,60) = 4.28, p = .043, \text{power} = .518$]. The effect of arrow cues on the FA rate was thus not significantly different from the effect of social cues on the FA rate, nor was it significantly different from the (nonsignificant) effect of peripheral cues on the FA rate. One interpretation of this analysis is that arrow cues merely have a weak effect on FA rates.

As a second analytical approach, we considered only the effect size of the FA cuing effects. We calculated effect sizes (Cohen's d) of cuing on FAs for each experiment using the G*Power program (Faul, Erdfelder, Lang, & Buchner, 2007). The effect sizes of the FA cuing effects in Experiments 1 (gaze cues) and 2 (hand cues) were medium ($d = 0.50$ and $d = 0.51$, respectively); in Experiment 3 (arrow cues), the effect size was small ($d = 0.26$); and in Experiment 4 (peripheral cues), it was negligible ($d = 0.06$), according to standard conventions (Cohen, 1992). Given this analysis, the best description of the data is that the effect of arrow cues on FA rates fell between the negligible effect of peripheral cues on FA rates and the significant effect of social cues on FA rates.

There are at least four explanations for the relatively weak effect of arrow cues on the FA rate. First, individual differences may somehow contribute to the strength or frequency of orienting from arrow cues (Tipples, 2008). Second, it may be that social cues have greater potential to recruit attentional processes than do non-social cues (Tipper et al., 2008). Tipper et al. observed a greater BOLD (blood-oxygenation-level-dependent) signal in frontal and occipital regions, and a greater P1 (ERP) amplitude, to targets following cues that were interpreted as gaze than to those that were interpreted as arrows. They argued that the attentional differences between social and arrow cues are simply quantitative,

not qualitative. It is possible that our results extend this quantitative distinction between social and arrow cues to nonattentional decision processes. Third, methodological differences between experiments might have contributed to FA cuing effects. Note that we used placeholders in Experiments 3 and 4 (a common procedure in studies of nonpredictive peripheral- and predictive arrow-cuing studies; e.g., Ivanoff & Klein, 2001; Klein & Hansen, 1990; Posner & Cohen, 1984), but there were no placeholders in Experiments 1 and 2 (common in studies of gaze cuing; e.g., Ristic et al., 2002; Tipples, 2002). It is unlikely that placeholders were responsible for reducing or eliminating the FA cuing effects in Experiments 3 and 4, however, given that placeholders have been used in experiments that revealed the effects of IOR on FA rates (e.g., Ivanoff & Klein, 2001). Lastly, arrow cues may have two effects: one like the effect of social cues on the decision criteria, and the other like the early attentional effect of nonpredictive peripheral cues. Combining these effects might dampen any influence of arrow cues on the FA effect. These ideas are speculative and therefore warrant future research on the nonattentional effects of arrow cues.

The Impact of Central Cuing on the Decision Criterion

Previous studies of IOR (e.g., Ivanoff & Klein, 2001, 2004) have found evidence of a response bias away from the cue (i.e., slower responding, and fewer FAs, to cued targets). The bias we have demonstrated here, using central cues, is toward the cued location, however, rather than away from it (i.e., faster responding, and more FAs, to cued targets). This is not to say that the mechanism that slows responding in IOR must be the converse of the mechanism that speeds responding with central cuing. Instead, it seems that nonpredictive central cues and IOR effectively bias responding in a contrary manner.

A recent study (Prinzmetal et al., 2008) failed to find any effect of gaze cuing on the accuracy of target identification. Prinzmetal et al. (2008) argued that gaze cues briefly preactivate responding toward the cue location, effectively raising the starting point from which target evidence accrues to a threshold. They argued that this rise in baseline activity is temporary and that it dissipates with time. A rise in baseline activity speeds RTs, but it should have little effect on error rates when all targets are equiprobable. There is at least one other mechanism that can explain their findings, however. A shift in the decision criterion (i.e., the degree of evidence that is required to make a decision) and a baseline shift (i.e., an initial tendency to favor one alternative over another) are mathematically equivalent: Both mechanisms effectively reduce the evidentiary distance between the starting point and the threshold. To further complicate matters, these mechanisms (i.e., criterion and baseline shifts) are not necessarily mutually exclusive. It is possible that some process shifts the baseline and the decision criterion simultaneously, perhaps even at different information-processing stages (see, e.g., Ivanoff, Branning, & Marois, 2008).

What are the effects of nonpredictive central cues on information processing? There are at least three possibilities. First, nonpredictive central cues may not evoke a shift of attention. Instead, the effect of the cues on RTs may be due entirely to a response bias (i.e., a baseline or criterion shift). Detection studies of gaze and arrow cuing cannot directly refute this possibility, because they do not measure accuracy. Also, this account cannot readily explain the increase in N1 and P1 ERP components with nonpredictive gaze cues (Schuller & Rossion, 2001). Moreover, it cannot readily explain the positive effect of gaze cues on accuracy in some discrimination tasks (e.g., Bayliss & Tipper, 2006b). For these reasons, an account of nonpredictive central cuing that is based solely on a response bias is tentative at best.

Second, nonpredictive central cues may recruit the same processes that predictive central cues recruit (Vecera & Rizzo, 2004, 2006). Vecera and Rizzo (2004, 2006) provided evidence, from a single patient, that damage to the frontal lobe eliminates nonpredictive and predictive central cuing effects (from word and gaze cues), but it does not affect peripheral cuing effects. Note, too, that Gibson and Bryant's (2005) findings suggest that endogenous processes influence the orienting effects of nonpredictive arrow cues. According to Vecera and Rizzo (2004, 2006), central directional cues (e.g., words, arrows, gaze) create associations with locations. These learned associations tend to evoke a shift of endogenous (voluntary) attention, because these cues are generally reliable in real-world settings. Arrows faithfully point to destinations when we are lost, and deviations in gaze may signal the intentions of the gazer. Orienting in the direction that is specified by these cues is voluntary, because gaze, and sometimes arrows, can be ambiguous. The gazer may be trying to deceive, and an arrow may not necessarily point to one's preferred destination. This account may readily explain the effect of orienting on RTs and the FA rate, given that the effects of endogenous orienting have been connected to early perceptual processing and the decision criterion (Handy et al., 2001; Klein, 1994; Klein & Hansen, 1990); however, there are some difficulties with this account. First, there is no *a priori* reason to voluntarily orient in the direction of a nonpredictive cue. After all, the cue provides no meaningful information regarding the location of the upcoming target. Second, orienting attention according to the direction of a central cue occurs even when the cue is counterpredictive (Driver et al., 1999; Friesen et al., 2004; Tipples, 2008). For these reasons, it seems unlikely, although not completely implausible, that nonpredictive central cues recruit only endogenous shifts of attention.

A final possibility is that nonpredictive central cues trigger shifts of the decision criterion and exogenous attention. The coexistence of these processes does not seem to be obligatory, given that there was no evidence in the present study of a lowered criterion with peripheral cues. Why might nonpredictive cues affect both exogenous attention and the criterion? Perhaps the overlearned associations that were discussed earlier generate something like an automatic expectancy (e.g., Matt, Leuthold, & Som-

mer, 1992), implemented as a criterion shift, for targets to appear at the cued location. In addition, the overlearned association, between gaze or arrow and a spatial direction, may trigger a shift of exogenous attention. This shift of attention may be affected by top-down mechanisms (see, e.g., Gibson & Bryant, 2005), but it is not necessarily endogenous. A reflexive shift of attention from a central cue may explain why the deceitful gazer often fools us, and why we may follow arrows to the wrong place when we are inattentive. This interpretation is tentative, of course, and further research is necessary to properly assess the claim that overlearned associations trigger reflexive shifts of attention.

Conclusion

Using a go/no-go task, we have discovered that nonpredictive social cues, and potentially arrow cues, speed RTs to targets at the cued location while also increasing the propensity to commit FAs to the cued location. We did not find any effect of peripheral cues on the FA rate. This dissociation suggests that nonpredictive central cues and nonpredictive peripheral cues do not recruit comparable cognitive mechanisms. The present results also provide the first evidence that nonpredictive central cues do more than affect attention.

AUTHOR NOTE

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