'Rare' emotive faces and attentional orienting

Gustav Kuhn[1], Alan Pickering[1] & Geoff G. Cole[2]

1) Department of Psychology, Goldsmiths, University of London, UK

2) Centre for Brain Science, University of Essex, UK

Key words: attention, social attention, gaze cueing, emotion, habituation

Running head: Emotional gaze cueing

Word Count: 2485

Correspondence should be addressed to:

Geoff G. Cole
Centre for Brain Science
University of Essex
Wivenhoe Park
Colchester
CO4 3 SQ
E-mail: ggcole@essex.ac.uk
Tel: 01206 872331
Fax: 01206 873801

Abstract:

The behavioural urgency hypothesis suggests that stimuli signalling potential danger will receive attentional priority. However, results from the gaze cueing paradigm have failed to consistently show that emotional expression modulates gaze following. One possible explanation for these null results is that participants are repeatedly exposed to the same emotional expressions during the typical gaze cueing procedure. We employed a relatively novel gaze cueing method in which participants were presented with two unique (or 'rare') trials during an experimental block. Specifically, either two fearful face trials appeared within a block of happy faces or two happy face trials appeared within a block of fearful faces. Results showed that when participants were repeatedly exposed to the same emotional expression gaze cueing was independent of face type. However, when the emotional expression was a rare event, significantly larger cueing occurred for fearful than for happy faces. These results support the behavioural urgency hypothesis and show that emotional expression does indeed modulate gaze following.

Introduction:

One of the central goals of the human visual system is to rapidly locate and process important events that may have implications for survival. For instance, new objects and motion onset are particularly effective at shifting an observer's attention (e.g., Abrams & Christ, 2003; Cole, Kentridge, Gellatly, & Heywood, 2003). Although most authors agree that changes in 'low-level' properties (e.g., luminance change) of the visual environment are particularly effective at attracting attention, debate surrounds whether changes processed by 'higher' mechanisms (e.g., emotion) can attract attention to a similar degree. Franconeri and Simons (2003) put forward the *behavioural urgency hypothesis*, arguing that a stimulus may be afforded processing priority if it signals potential danger. These authors showed that a stimulus that looms towards an observer is more effective at capturing attention compared with a stimulus that recedes away from the observer, particularly if the object is on a direct collision path with the observer compared to a near-miss path (Lin, Franconeri, & Enns, 2008).

Given the importance of orienting attention to potential danger, one might expect 'gaze following' to be particularly strong when it coincides with cues that are indicative of threat, such as a fearful emotional expression. Gaze following is typically investigated using a Posner-type cueing paradigm (Posner, 1980) in which participants are required to detect a target that is either looked at by a centrally presented face ('valid cue'), or appears in a non looked-at location ('invalid cue'; Friesen & Kingstone, 1998). Participants are typically faster at detecting validly cued targets compared with invalidly cued targets (for review see Bayliss, Frischen, Fenske, & Tipper, 2007). Although the behavioural urgency hypothesis predicts that gaze cueing should be influenced by emotional expression since it may be an indicator of threat, the empirical support for this interaction is rather mixed. In an early series of (six) experiments, Hietanen and Leppanen found no influence of emotional expression on gaze cueing (2003), a finding that has been replicated by several others (Bayliss et al., 2007; Pecchinenda, Pes, Ferlazzo, & Zoccolotti, 2008). That said, under some conditions, gaze cueing is modulated by emotion. For example, individuals with high levels of anxiety show stronger gaze cueing in response to fearful as opposed to neutral faces (Fox, Mathews, Calder, & Yiend, 2007; Mathews, Fox, Yiend, & Calder, 2003; Tipples, 2006). Furthermore, in the standard gaze cueing experiments, participants are required to search for neutral targets (e.g., the onset of a dot) and the task does not involve any emotive component. In this context, Fichtenholtz el al. (2007; see also Bayliss, Schuch, & Tipper, 2010; Kuhn & Tipples, 2011) showed that when participants were required to detect an emotionally salient target, the emotional expression did influence gaze cueing with stronger cueing for fearful than for happy faces.

Putman et al. (2006) have suggested that the general failure to demonstrate an interaction between gaze and emotion may reflect limitations of the standard gaze cueing paradigm, and in particular the use of static displays. Furthermore, and central to the present work, participants are typically exposed to hundreds of trials, and response times (RTs) are averaged across all of these. Whilst large trial numbers are clearly a necessary requirement for many attention experiments, they raise questions as to how representative these task are and whether they provide a good index of social cognition. It is possible that repeated exposure to the same faces and expressions reduces any potential behavioural differences. This is particularly relevant to the behavioural urgency hypothesis where processes associated with the detection of threat (i.e., ‘urgency’) are likely to be susceptible the effects of repeated exposure. Presumably, a stimulus that is potentially threatening when first seen will no longer be so when presented repeatedly without adverse consequences.

The aim of the current experiment was to examine the behavioural urgency hypothesis and investigate whether fearful faces increase gaze following when participants have not been repeatedly exposed to the same emotional expression. We employed a relatively novel gaze cueing method in which participants were presented with two unique (or ‘rare’) trials during a block. Two blocks of trials were presented in which the face morphed from a neutral expression to a happy expression in one block, whilst on another block the face morphed from a neutral to a fearful expression. Critically, on two trials in the happy face block the face morphed to a fearful expression whilst on two trials in the fearful block the face morphed into a happy expression. Given the potential importance of a fearful expression, we predicted that a rare emotive event would induce a stronger cueing effect for fearful faces (embedded amongst many happy faces) than for happy faces (embedded amongst many fearful faces).

Method

Participants. There were 74 participants (46 f) whose age ranged from 18-24. All were undergraduate psychology students at the University of Essex[1]. The study received departmental ethical approval and participants received course credits for their participation.

Stimuli and apparatus. The gaze cue was a computer generated male face presented in the centre of the display, measuring 10.4° in height and 7.1° in width. Trials began with the presentation of a (neutral) face for 1000 ms before its eyes moved smoothly to the side over the course of 150 ms. Simultaneously with the gaze shift the face morphed into either a happy expression or fearful. Immediately after the gaze shift was completed, either the letter L or T was presented as the target. When viewed from approximately 60 cm each letter measured 1.3° in height and 0.86° in width. The letters were grey against a black background (40.5 cd/m^2 and 0.3 cd/m^2 respectively) and appeared 6.5° from the centre of the display. The experiment was carried out in a well-lit room and was driven by an iMac comprising a CRT monitor.

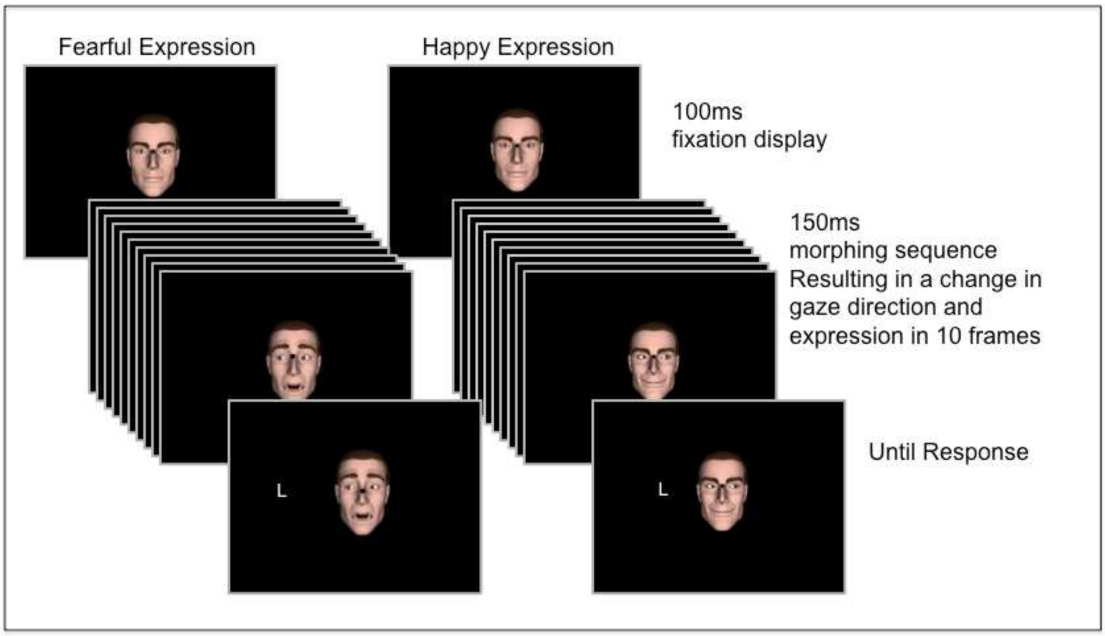

Figure 1*: Order of events for a valid fearful trial and an invalid happy trial. After a fixation display (1000ms) a 150ms dynamic sequence occurred displaying 10*

gradual transitions from a neutral to a fearful/happy expression whilst the eyes simultaneously shifted to one side. Immediately after the transition the target (letter L) or a catch trial (letter T) appeared (Figures not drawn to scale).

Design and procedure. A 2x2x2 design was employed, with validity (valid, invalid), emotional expression (happy, fear) and likelihood (common, rare) as within-participants factors. Ninety-seven trials were presented in each of two blocks making a total of 194. Thirty-six per block were 'catch trials'. In the happy block, 95 trials were presented in which the face morphed from a neutral expression to a happy expression. On a further two trials the face morphed into a fearful expression. On one of these rare trials the face provided a valid cue whilst on the other the face provided an invalid cue. The design of the fearful block was identical, e.g., 95 trials in which the face morphed to a fearful expression and two trials in which it morphed to a happy expression. The presentation order of the happy and fearful blocks was counterbalanced. Because the rare-event design necessarily presents the critical trials infrequently (two trials per block in the present case) we incorporated a design feature that attempted to minimise response noise. Clearly, target processing and RTs are influenced by many factors. For instance, target position, target on trial n-1, target on trial n-2, and response hand used on trial n-1, can all differentially affect responses (see, Hillstrom, 2000). To minimise noise resulting from these effects, the sequence of the seven trials that immediately preceded both rare trials was identical. For instance, trial n-3 presented a left-looking face, with the letter L appearing on the right. Similarly, trial n-1 presented a right-looking face, with the letter L appearing on the left. This ensured that all target and response processing that preceded the two rare trials were identical for both. Furthermore, on the two rare trials the target always occurred on the right with only the direction of gaze being different. However, the presentation order of the two rare trials was counterbalanced. Thus, half the participants were presented with a rare valid trial first whilst the other half were presented with a rare invalid trial first. These two trials were presented at trial number 48 and 96 out of the 97. Participants were asked to press the space bar on a standard keyboard when the letter L appeared and withhold a response when a T was presented. The latter were designed as 'catch' trials. The beginning of a trial was initiated by the participant's response on the previous trial.

Results:

Data from three participants were excluded as they responded on more than 50% of the catch trials.

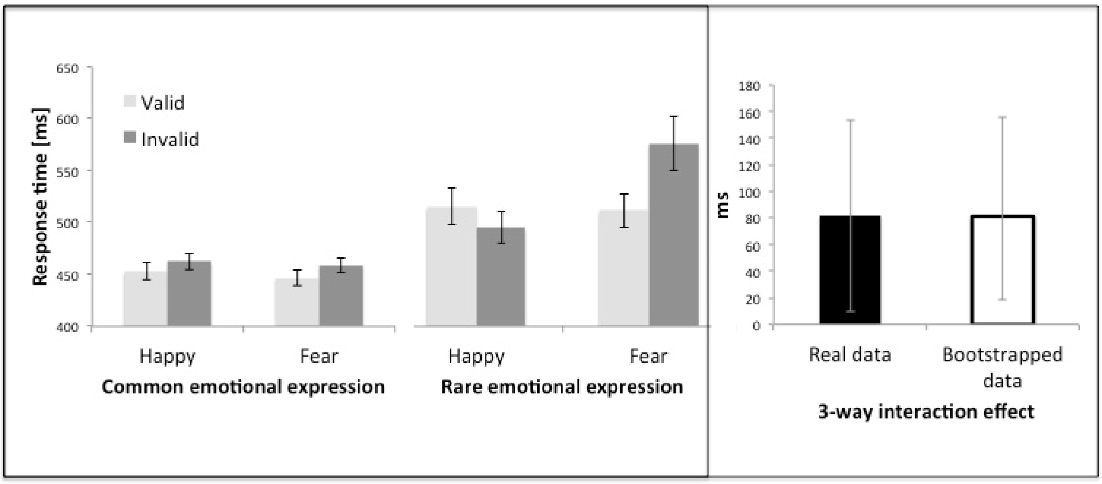

Figure 2: Left panel: Mean RTs for validity (valid vs. invalid) as a function of the emotional expression (happy vs. fear) and the likelihood of the emotional expression (common vs. rare). Error bars denote standard errors. The happy,

common emotional expression refers to a block in which the face morphed to a happy expression on the majority of trials, whilst the happy, rare emotional expression refers to the two trials in which the happy face was embedded amongst a block of fearful faces. The same principle applies to the fear expression. Right panel: The size of the 3-way interaction effects with 95% confidence limits are shown for the real data and for 1000 bootstrapped resamples from these data. Note the real and bootstrapped data are almost identical and both are significantly different from zero, p<0.05

The central result concerns the three-way ANOVA with validity, emotion and likelihood as within-participant factors. This revealed a significant three-way interaction, $F(1, 70) = 5.05$, $p = .028$, $\eta^2 = .067$, illustrating that the effect of emotion on validity depended on whether the emotional expression was common or rare. It is clear from the error bars on Figure 2 that the error variation differs quite markedly between the common and rare conditions (naturally, given that the latter are based on one trial per condition). We checked the validity of this interaction using a resampling approach (Good, 2005), in which a large number of resampled data sets (1000) were created by taking each participant's set of eight mean RTs and permuting the values randomly across the eight cells. If a particular statistic is computed for each resampled dataset then the distribution of that statistic, across the resampled datasets, can be used as data-driven non-parametric sampling distribution of the statistic under the null hypothesis. For these data the F statistic for the three-way interaction was assessed against the randomisation sampling distribution and the p value was 0.027, very close to the 0.028 based on the theoretical F-distribution. We also ran various bootstrapping analyses which also confirmed our ANOVA results nonparametrically (See figure 2).

Next we performed two separate 2x2 ANOVAs on common and rare expressions. When the emotional expression was common there was a significant main effect of validity, $F(1, 70) = 15.2$, $p < .0005$, $\eta^2 = .178$, but no effect of emotion $F(1, 70) = 1.84$, $p = .18$, $\eta^2 = .026$, and no significant emotion by validity interaction, $F(1, 70) <1$. Furthermore, the cueing effect was significant for both happy, t(70 = 2.30, $p = .024$, d = .28, and fearful faces, $t(70) = 4.19$, $p < .0005$, d = .45. When the emotional expression was rare, there was a significant main effect of emotion, $F(1, 70) = 4.46$, $p = .038$, $\eta^2 = .06$, but no significant main effect of validity, $F(1, 70) = 1.26$, $p = .265$, $\eta^2 = .018$. Crucially, there was a significant emotion by validity interaction, $F(1, 70) = 5.77$, $p = .019$, $\eta^2 = .076$. Whilst the cueing effect was significant for the fearful faces, $t(70) = 2.03$, $p = .046$, d = .25, there was no significant difference between valid and invalid trials for the happy faces, $t(70) = 1.00$, $p = .32$, d = .12.

Other analysis revealed that RTs for common emotions were significantly faster than for rare emotions, $F(1, 70) = 42.5$, $p < .0005$, $\eta^2 = .378$, but there was no significant main effect of emotion, $F(1, 70) = 3.48$, $p = .066$, no main effect of validity $F(1, 70) = 2.65$, $p = .11$, $\eta^2 = .036$, and no likelihood by validly interaction $F(1, 70) < 1$. There was however a significant likelihood by emotion interaction $F(1, 70) = 5.10$, $p = .027$, $\eta^2 = .068$.

Discussion

We investigated whether fearful faces influence gaze cueing more than happy faces when the emotional expression is a rare event. As set out in the Introduction, there is good theoretical reason to predict why fearful faces should result in stronger gaze cueing than happy faces. The behavioural urgency hypothesis (Franconeri & Simons, 2003) states that stimuli signalling potential danger receive processing priority. It follows therefore that a fearful face should cue attention more than a happy face. We found that when participants were repeatedly exposed to the same face (i.e., large numbers of fearful or happy face trials), there was no significant difference in the gaze cueing effect for fearful and happy faces. However, when the emotional face was a rare event, fearful faces produced significantly stronger cueing than the happy faces.

In addition to the basic finding, condition means demonstrate that responses times were slower for the rare trials compared with the trials that were repeatedly presented. In other words, as one might expect, an unexpected emotion held attention for longer. This concurs with an abundance of work showing that novel stimuli receive attentional priority (e.g., Berlyne, 1970). However, perhaps more importantly is the effect observed *after* attention had been withdrawn from the face. The data show that the basic cueing effect was primarily driven by a slowing of responses for targets presented in the invalid fearful expression condition. This shows that although the fearful face did not shift attention more rapidly compared with the happy face, once attention was shifted it could not be easily disengaged from the location gazed-at by a fearful expression. This concurs with what might be expected from the behavioural urgency hypothesis; despite the current goal (i.e., letter identification), attentional mechanisms lead to an increase in the time spent processing a potentially important stimulus.

The absence of an effect of emotion on gaze cueing on trials that were repeatedly presented is in line with previous research (Bayliss et al., 2007; Hietanen & Leppanen, 2003; Pecchinenda et al., 2008). Our findings suggest that the null effects previously reported may reflect limitations in the gaze cueing paradigm, rather than true independence of gaze cueing and emotional expression. Moreover, we predict that paradigms such as the dot-probe task, which is commonly used to measure attentional capture and engagement by emotional stimuli (e.g. Fox, Russo, & Dutton, 2002), will yield stronger effects using the rare-trial method. The probable increased sensitivity of the rare-trial method is supported by results from previous attention experiments that have also employed a novelty/surprise paradigm. For instance, a long debate surrounds the issue of what stimulus types automatically attract attention (e.g. Franconeri, Hollingworth, & Simons, 2005; Hillstrom & Yantis, 1994; Yantis & Jonides, 1990). Central to this debate is the 'feature singleton'; that is, a unique feature (e.g., a red square) that appears amongst an array of homogenous items (e.g., green squares Cole, Kuhn, Heywood, & Kentridge, 2009; Jonides & Yantis, 1988). Many authors argued that such a stimulus should attract attention due to its status as a novel item. However, evidence for capture by such features has been mixed (e.g., Folk & Annett, 1994; Gibson & Jiang, 1989; Yantis & Egeth, 1999). By contrast, Horstmann (2002) showed that RTs to discriminate a target were reduced when it occurred at the location of a surprise singleton. Thus, this study, together with the present findings, challenge the validity of the paradigms commonly used to index attentional capture.

In sum, our results show that when participants have not been repeatedly exposed to an emotional expression, fearful faces result in stronger gaze cueing than happy faces. This is in line with the behavioural urgency hypothesis which states that processing priority will be afforded stimuli that signal potential danger.

Footnote.

1. Typical gaze cueing experiments use between 16–30 participants. However, as our experiment used a single trial analysis in some conditions we required a substantially larger sample.

References

Abrams, R. A., & Christ, S. E. (2003). Motion onset captures attention *Psychological Science* (Vol. 14, pp. 427-432).

Bayliss, A. P., Frischen, A., Fenske, M. J., & Tipper, S. P. (2007). Affective evaluations of objects are influenced by observed gaze direction and emotional expression. *Cognition, 104*(3), 644-653.

Bayliss, A. P., Schuch, S., & Tipper, S. P. (2010). Gaze cueing elicited by emotional faces is influenced by affective context. *Visual Cognition, 18*(8), 1214-1232.

Berlyne, D. E. (1970). Novelty, complexity, and hedonic value. *Perception & Psychophysics, 8*, 279-286.

Cole, G. G., Kentridge, R. W., Gellatly, A. R. H., & Heywood, C. A. (2003). Detectability of onsets versus offsets in the change detection paradigm. *Journal of Vision, 3*(1), 22-31.

Cole, G. G., Kuhn, G., Heywood, C. A., & Kentridge, R. W. (2009). The Prioritization of Feature Singletons in the Change Detection Paradigm. *Experimental Psychology, 56*(2), 134-146. doi: 10.1027/1618-3169.56.2.134

Fichtenholtz, H. M., Hopfinger, J. B., Graham, R., Detwiler, J. M., & Labar, K. S. (2007). Happy and fearful emotion in cues and targets modulate event-related potential indices of gaze-directed attentional orienting. *Social cognitive and affective neuroscience, 2*(4), 323-333.

Folk, C. L., & Annett, S. (1994). Do locally defined features discontinuities capture attention. *Perception & Psychophysics, 56*(3), 277-287. doi: 10.3758/bf03209762

Fox, E., Mathews, A., Calder, A. J., & Yiend, J. (2007). Anxiety and sensitivity to gaze direction in emotionally expressive faces. *Emotion, 7*(3), 478-486. doi: 10.1037/1528-3542.7.3.478

Fox, E., Russo, R., & Dutton, K. (2002). Attentional bias for threat: Evidence for delayed disengagement from emotional faces. *Cognition & Emotion, 16*(3), 355-379. doi: 10.1080/02699930143000527

Franconeri, S. L., Hollingworth, A., & Simons, D. J. (2005). Do new objects capture attention? *Psychological Science, 16*(4), 275-281.

Franconeri, S. L., & Simons, D. J. (2003). Moving and looming stimuli capture attention. *Perception and Psychophysics, 65*, 999-1010.

Friesen, C. K., & Kingstone, A. (1998). The eyes have it! Reflexive orienting is triggered by nonpredictive gaze. *Psychonomic Bulletin & Review, 5*(3), 490-495.

Gibson, B.S., & Jiang, Y. (1989). Surprise! An Unexpected Color Singleton Does Not Capture Attention in Visual Search. *Psychological Science, 9*, 176-182.

Good, P.I. (2005). *Resampling Methods: A Practical Guide to Data Analysis*: Wiley.

Hietanen, J. K., & Leppanen, J. M. (2003). Does facial expression affect attention orienting by gaze direction cues? *Journal of Experimental Psychology-Human Perception and Performance, 29*(6), 1228-1243. doi: 10.1037/0096-1523.29.6.1228

Hillstrom, A. P., & Yantis, S. (1994). Visual-Motion and Attentional Capture. *Perception & Psychophysics, 55*(4), 399-411.

Horstmann, G. (2002). Evidence for attentional capture by a surprising color singleton in visual search. *Psychological Science, 13*(6), 499-505.

Jonides, J., & Yantis, S. (1988). Uniqueness of abrupt visual onset in capturing attention. *Perception & Psychophysics, 43*(4), 346-354.

Kuhn, G., & Tipples, J. (2011). Increased gaze following for fearful faces. It depends on what you're looking for! *Psychonomic Bulletin & Review, 18*(1), 89-95. doi: 10.3758/s13423-010-0033-1

Lin, J., Franconeri, S.L., & Enns, J.T. (2008). Objects on a collision path with the observer demand attention. *Psychological Science, 19*(7), 686-692.

Mathews, A., Fox, E., Yiend, J., & Calder, A. (2003). The face of fear: Effects of eye gaze and emotion on visual attention. *Visual Cognition, 10*(7), 823-835.

Pecchinenda, A., Pes, M., Ferlazzo, F., & Zoccolotti, P. (2008). The combined effect of gaze direction and facial expression on cueing spatial attention. *Emotion, 8*(5), 628-634. doi: 2008-13989-004 [pii]
10.1037/a0013437

Posner, M. I. (1980). Orienting of Attention. *Quarterly Journal of Experimental Psychology, 32*, 3-25.

Putman, P., Hermans, E., & Van Honk, J. (2006). Anxiety meets fear in perception of dynamic expressive gaze. *Emotion, 6*(1), 94-102.

Tipples, J. (2006). Fear and fearfulness potentiate automatic orienting to eye gaze. *Cognition & Emotion, 20*(2), 309-320.

Yantis, S., & Egeth, H. E. (1999). On the distinction between visual salience and stimulus-driven attentional capture. *Journal of Experimental Psychology-Human Perception and Performance, 25*(3), 661-676.

Yantis, S., & Jonides, J. (1990). Abrupt Visual Onsets and Selective Attention - Voluntary Versus Automatic Allocation. *Journal of Experimental Psychology-Human Perception and Performance, 16*(1), 121-134.