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REPORT

Eye remember you: the effects of gaze direction on face recognition in children and adults

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Abstract

Children and adults were tested on a forced-choice face recognition task in which the direction of eye gaze was manipulated over the course of the initial presentation and subsequent test phase of the experiment. To establish the effects of gaze direction on the encoding process, participants were presented with to-be-studied faces displaying either direct or deviated gaze (i.e. encoding manipulation). At test, all the faces depicted persons with their eyes closed. To investigate the effects of gaze direction on the efficiency of the retrieval process, a second condition (i.e. retrieval manipulation) was run in which target faces were presented initially with eyes closed and tested with either direct or deviated gaze. The results revealed the encoding advantages enjoyed by faces with direct gaze was present for both children and adults. Faces with direct gaze were also recognized better than faces with deviated gaze at retrieval, although this effect was most pronounced for adults. Finally, the advantage for direct gaze over deviated gaze at encoding was greater than the advantage for direct gaze over deviated gaze at retrieval. We consider the theoretical implications of these findings.

'The difference in human features must be reckoned great, inasmuch as they enable us to distinguish a single known face among those of thousands of strangers, though they are mostly too minute for measurement. At the same time, they are exceedingly numerous. The general expression of a face is the sum of a multitude of small details, which are viewed in such rapid succession that we seem to perceive them all at a single glance.' (Galton, 1883, p. 3)

Introduction

As Galton (1883) noted, the human capacity for face recognition is quite remarkable. In comparison to most other types of stimuli, faces are more alike than dissimilar and yet, we are capable of recognizing thousands of individual faces. While the many features of the face must support the process of stimulus discrimination, most researchers in the field agree that the eyes have a privileged role as the primary focus of an observer's attention. Recordings of scanning patterns reveal that both adults (Yarbus, 1967) and infants (Maurer & Salapatek, 1976) preferentially fixate on the eye region when viewing faces. We attend to the eyes because they indicate where the other person's attention is focused. As such, gaze direction serves as a valuable source of non-verbal information (Argyle & Cook, 1976).

It comes as little surprise, therefore, to learn that humans are extremely sensitive to eye direction and are capable of discriminating very small deviations in gaze (Anstis, Mayhew & Morley, 1969). This behavioural sensitivity accords with accumulating evidence for specialized gaze detectors within the primate visual system. Many cells in the monkey superior temporal sulcus (STS) respond selectively to the direction of seen gaze (Perrett & Mistlin, 1990). Electrophysiological studies of humans also reveal an event-related potential (ERP) component that may be sensitive specifically to the eyes (Bentin, Allison, Puce, Perez & McCarthy, 1996). Furthermore, lesion studies of patients with inferotemporal damage, and related monkey studies, also suggest that there may be specialized direction-of-gaze detectors (Campbell, Heywood, Cowey Regard & Landis, 1990). Finally, functional imaging studies have also revealed that direction of gaze in faces preferentially activates

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regions of the human STS (Hoffman & Haxby, 2000). However, direction of gaze is not entirely independent of facial context as the orientation of the head can also modulate the perceived direction of attention (Langton, Watt & Bruce, 2000).

Noting the importance of gaze detection in social interaction, recent years have witnessed a growing interest in eye gaze as an attentional mechanism. Studies measuring speeded responses to peripheral targets have found that if the target position is cued by deviated eyes of a face presented at fixation, performance is facilitated compared to trials in which the eyes point in the opposite direction (Driver, Davis, Ricciardelli, Kidd, Maxwell & Baron-Cohen, 1999; Friesen & Kingstone, 1998). Indeed, even 3-month-old infants show this attentional cueing effect of eye gaze (Farroni, Johnson, Brockbank & Simion, 2000; Hood, Willen & Driver, 1998). Moreover, unlike non-social cues such as arrows, the attentional effects of eye gaze are obligatory. Even when observers are told explicitly to ignore the eyes, or the eyes point in the opposite direction on most of the target trials, attention is still shifted in the direction of gaze, thereby indicating that people have a strong propensity to follow another's line of sight (Driver *et al.*, 1999; Freisen & Kingstone, 1998).

Taken together, this electrophysiological, neuropsychological, imaging and behavioural evidence suggests that direction of gaze is an important feature of faces. Moreover, the behavioural data indicate that the direction of eye gaze may be critical in face processing tasks which require attention, particularly tasks that capture the importance of gaze direction in human social cognition. One such task, for example, is person categorization. When participants are required to judge whether a face is male or female, gender categorization is speeded when the eyes are staring compared to when they are either deviated or closed (Macrae, Hood, Milne, Rowe & Mason, in press). If then gaze moderates the efficiency of categorical processing (i.e. person construal), then so too it may affect other social-cognitive tasks with attentional components, such as face recognition. Keeping track of the individuals that one has encountered is a basic problem in social cognition. One might therefore expect gaze direction to be an important determinant of the accuracy of face recognition. As the most socially relevant targets are usually those with whom mutual eye contact has been established, it is possible that face recognition may be enhanced for faces with direct rather than averted gaze.

As attentional processes can operate at different stages of face processing, in the present investigation we decided to manipulate direction of gaze during both the encoding and retrieval phases of a face recognition task. Pilot studies of children and adults have revealed that the optimal configuration for face recognition is to have faces with direct gaze at both the study and test phases of a recognition task (Kelly, 2001). While interesting, this finding necessarily obscures the important issue of where exactly the effects of eye gaze are operating in face recognition: at encoding, at retrieval, or perhaps at both stages of the recognition process. In the present study we sought to clarify this ambiguity by attempting to isolate the independent effects of gaze direction during both the encoding and retrieval phases of a face recognition task. In the encoding version of the task, the to-be-studied faces displayed either direct or laterally averted gaze. At test, all the faces (i.e. targets and foils) were presented with their eyes closed. In the retrieval version of the task, this sequence was reversed. At study all the faces were presented with their eyes closed. At test, however, the faces were depicted with either direct or laterally averted gaze. Through the adoption of such a paradigm, it is possible to investigate the independent effects of gaze direction, particularly staring eyes, on the encoding and retrieval phases of face recognition.

While it is generally accepted that adults process faces holistically, there is still debate about the face processing style that is adopted by children. In particular, developmental studies of face processing have concentrated on a transition in face recognition performance at around 6 years of age which has been interpreted as a switch in encoding from a piecemeal to a more holistic processing style (Carey & Diamond, 1977; Carey, Diamond & Woods, 1980). However, the switch hypothesis is contentious as others have found evidence for configural processing at this age when different procedures (Tanaka, Kay, Grinnell, Stansfield & Szechter, 1998) or different analysis are used (Flin, 1985). Moreover, infants show hemispheric specialization within the first year of life with the right hemisphere using configurational processes during face recognition (Deruelle & de Schonen, 1998). This undermines the late emergence of this ability as advocated by the switch hypothesis.

The present study sought to examine the role of gaze direction in face recognition in 6-year-olds and adults to determine whether comparable effects would emerge in both age groups. The problem for this type of investigation is that it is often difficult to find methodologies that overcome many of the performance differences that exist between adults and children. However, this is not so in the area of face recognition. The forced-choice recognition procedure in which target faces are presented serially and then presented again matched against a distractor face has been shown to be a robust and reliable measure of face recognition for both 6-year-olds and adults (Carey & Diamond, 1977; Carey *et al.*, 1980).

Accordingly, this paradigm was adopted in the experiment reported herein.[1]

Method

Participants and design

Participants were 40 adult undergraduates from the University of Bristol and 40 children selected from the Year 2 form of local junior schools. Half the adults were male and half were female. The age range of the adult group was between 18 and 21 years. Of the 40 children, 22 were female and 18 were male. The children were between 6 and 7 years of age. The experiment had a 2 (group: adults or children) × 2 (task: encoding or retrieval) × 2 (gaze: direct or deviated) mixed design with repeated measures on the second and third factors.

Stimulus materials and procedure

Face stimuli were selected from a database of Caucasian faces collected from the University of Bristol undergraduate population. Models were between 18 and 21 years of age. All images were cropped and altered to remove distinctive features such as jewellery. Models for the faces had been instructed to be expressionless and adopt four eye poses, staring ahead, closed, deviated left and deviated right. Half of the faces were male and half were female. In total, 4 stimulus sets were created with each set comprising 20 target and 20 distractor faces. This allowed each face to be a target for half the participants and a distractor for the remaining participants in each condition. This was done to avoid the possibility that a particular set of target faces was more memorable. The 20 to-be-studied faces were printed in monochrome on laminated (12 cm by 16 cm) cards. At test, 20 cards were presented to the participants. These cards displayed a target and distractor face. The faces were printed side by side on laminated (30 cm by 16 cm) cards. The distractor faces matched the target faces as closely as possible.

Participants completed both the encoding and retrieval versions of the task. The order in which the tasks were undertaken was counterbalanced. Participants were simply asked to look at a number of faces that were placed by the experimenter on a table in the laboratory. Each face was presented for 5 s and participants were not told that they would be tested on a subsequent memory task. In the encoding condition, the to-be-studied faces displayed either direct or deviated (left or right) gaze. In the retrieval condition, in contrast, the eyes were always closed. On completion of the viewing session, participants were informed that the purpose of the experiment was to test their memory for the faces they had previously seen. Participants were then presented with 20 pairs of faces, one pair at a time, and asked to point to the one they had seen before. They were given as much time as necessary to complete this task. For participants in the encoding condition, the test faces were depicted with their eyes closed. For participants in the retrieval condition, the test faces displayed either direct or deviated (left or right) gaze. Assignment of the faces to target and distractor sets was counterbalanced. On completion of the experiment, participants were debriefed, thanked for their assistance, and dismissed.

Results

The mean proportion of hits (i.e. correct recognitions) are listed in Table 1. A 2 (group: adults or children) × 2 (task: encoding or retrieval) × 2 (gaze: direct or deviated) mixed model analysis of variance revealed main effects of group [$F(1, 76) = 55.99$, $p < 0.001$] and gaze [$F(1, 76) = 30.99$, $p < 0.001$] on recognition performance. Recognition performance was better for adults than children and for faces with direct than deviated gaze. Importantly, however, the analysis also revealed a significant gaze × task interaction, $F(1, 76) = 3.76$, $p < 0.05$. No other main effects or interactions were significant. Post-hoc tests confirmed that, at encoding (i.e. eyes closed at test), recognition performance was better for faces with direct than deviated gaze, $t(39) = 4.74$, $p < 0.001$, $d = 0.76$. At retrieval, although the faces were initially encoded with their eyes closed, recognition performance was enhanced when the test faces displayed direct rather than deviated gaze, $t(39) = 2.99$, $p < 0.001$, $d = 0.48$. Thus, as expected, recognition performance was better for faces with direct than deviated gaze. Moreover, the memorial benefits of direct gaze were present at both the encoding and retrieval phases of face recognition. Interestingly, although these effects were not moderated by the age of the participants in that the interaction with age did not reach signficance, it would appear that only adults tended to display the benefits of direct gaze at retrieval (see Table 1).

Discussion

The present results support the prediction that face recognition is enhanced when targets display direct rather

[1] In a pilot study prior to the present investigation, we ran another 20 children on a forced-choice recognition task using faces in which the eyes were always closed. The mean proportion of correct responses was 0.71, thereby suggesting that the current methodology was suitable for testing face recognition in this age group.

Table 1 *Recognition performance (mean proportion correct and SD) as a function of group, task and gaze direction*

Gaze	Task			
	Encoding		Retrieval	
	direct	deviated	direct	deviated
Group				
adults	0.93 (0.11)	0.79 (0.12)	0.86 (0.11)	0.76 (0.14)
children	0.76 (0.15)	0.60 (0.13)	0.69 (0.13)	0.65 (0.14)
overall	0.84 (0.15)	0.70 (0.16)	0.78 (0.15)	0.70 (0.15)

than deviated gaze. This finding extends previous reports of the effects of eye gaze on person perception (Macrae *et al.*, in press) by demonstrating that direct gaze influences both the encoding and retrieval phases of face recognition in adults and children, although the effect of gaze direction at retrieval is most pronounced for adults. That encoding is optimized by direct gaze is consistent with one recent model of joint attention which argues that detecting the presence of eyes and whether or not they are looking towards the observer is a primary objective of the social brain (Baron-Cohen, 1995). In the encoding version of the present task, direct gaze could activate mutual gaze detectors, thus triggering facilitated encoding relative to faces displaying deviated gaze. In turn, this facilitated encoding would prompt enhanced memory for faces with direct gaze. What is particularly noteworthy about the present results, however, is that gaze direction also influenced the efficiency of the retrieval processes that support face recognition. When faces were initially encoded with their eyes closed, subsequent recognition of these items was enhanced when the test faces displayed direct rather than deviated eye gaze. This clearly demonstrates that gaze direction may be an important retrieval cue in face recognition. Again, however, shared gaze may be the mechanism through which this effect emerges. At test, shared gaze may prompt the elaborative processing of the available retrieval cue. In turn, this elaborative processing may increase the efficiency of the retrieval cue, thereby enhancing face recognition performance. One caveat is that while the findings are consistent with a face recognition mechanism, they are also consistent with a more general pattern recognition processor as the orientation of the faces is always constant. A true face recognition system should be capable of dealing with various changes in observer's viewpoint and so future studies should address this issue by presenting faces to be recognized in different orientations from the initial presentation (see Bruce, 1982).

It is worth noting that an alternative explanation may be offered for the present results. Previous studies of orienting have demonstrated obligatory shifts of attention when the eyes are laterally averted (Driver *et al.*, 1999, Friesen & Kingstone, 1998). Could it be, then, that participants in the present experiment were unable to process these faces efficiently as their attention was temporarily directed elsewhere? We think this is unlikely for a couple of reasons. First, these obligatory shifts in attention are typically confined to the first 200 ms of a processing episode (Friesen, Ristic & Kingstone, in press). In the present experiment, however, the faces were on view for 5 s and participants had unlimited time in which to make their decisions during the test phase of the task. It is therefore unlikely that covert shifts in attention impaired recognition performance for faces displaying deviated gaze. Second, in research that has measured the speed with which targets can be categorized according to gender, comparable reaction times have been reported for faces with deviated and closed eyes (Macrae *et al.*, in press). Again this speaks against the possibility that covert shifts of attention may be driving the effects observed for faces with deviated eyes in person perception tasks.

It could be that the effects of gaze direction in social-cognitive tasks are arousal based, with direct gaze increasing levels of arousal (Nichols & Champness, 1971), thus enhancing subsequent categorization and face recognition performance. Staring is known to activate centres associated with the task of evaluating the social relevance of stimuli. Recent neuroimaging research investigating the neural mechanisms that underlie the detection of eye gaze have shown that the amygdala is activated when eye gaze is directed towards a person (Kawashima, Sugiura, Kato, Nakamura, Hatano, Ito, Fukuda, Kojima & Nakamura, 1999). The amygdala is also known to play a crucial role in recognizing emotional expression in faces (Adolphs, Tranel, Damasio & Damasio, 1994). Other studies implicate the role of eye gaze on cortical mechanisms that respond to reinforcement. Direct gaze was found to modulate the influence of attractive faces on the ventral striatum, a region associated with reward prediction (Kampe, Frith, Dolan & Frith, 2001). It was argued that attractive faces were potentially rewarding, but only if the interaction was signalled by mutual gaze. These findings suggest that the amygdala and ventral striatum may form part of a dopaminergic system for evaluating the reward potential of social interaction. It seems plausible that such a system may be sensitive to the efficiency of face recognition, a process that is clearly modulated by a person's direction of gaze.

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