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The effect of gaze direction on human recognition memory for faces

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Abstract

The present study examined the effect of gaze direction on people’s recognition memory for faces. Gaze direction (direct or averted) and gaze manipulation phase (encoding or retrieval) were the main variables analyzed to determine if gaze direction affects the encoding or retrieval of faces. Based on previous research, the hypothesis was that direct gaze would lead to stronger memory for faces than averted gaze. It was also predicted that when gaze was manipulated at encoding, gaze effects would be stronger than when gaze was manipulated at retrieval. Subjects made age judgments about faces while viewing them three times, and were later tested on their memory for those faces. The results of Experiment 1 confirmed the direct gaze advantage over averted, although this was not the case across each and every condition. After analyzing the results of Experiment 1, Experiment 2 was designed to address a possible effect identified in Experiment 1. The order in which subjects completed two separate parts of the experiment seemed to play a role in modulating gaze effects in Experiment 1. Experiment 2 aimed at addressing this possible effect, but the results were less conclusive with no significant advantages identified. Combined analysis of parts of both experiments identified an overall advantage for direct gaze over averted, confirming the majority of previous research. No effect of gaze manipulation phase was identified overall, leaving room for further investigation of the gaze manipulation phase variable’s role in facial memory processes.
Introduction

In the early days of our species, humans probably relied on social cues from other humans and animals to anticipate threats and avoid danger. Locking eyes with a predator may have been an indication to seek refuge, while observing the gaze of another intensely focused behind you might cause you to turn around. In today’s highly populated and interactive society, humans must still utilize the cues and clues available to them to navigate life’s many different social situations. Interpersonal contact occurs often, and one must constantly assess group and one-on-one interactions by interpreting the bodily and behavioral signals of others. In order to understand the social world around us, it is important to correctly perceive and interpret the information that the faces of others convey. Memory for the faces that one has come across in the past is also a key aspect of interacting with others and forming relationships. This study will attempt to examine the effect of eye gaze direction on people’s recognition memory for faces.

Facial Perception

Facial perception is important for navigating social situations, and is possibly humans’ most advanced visual skill (Haxby, Hoffman & Gobbini, 2000). Without being able to quickly and accurately perceive and process the faces of others, daily life would be much more difficult. Some people suffer from a condition known as prosopagnosia, or inability to recognize faces. Prosopagnosia studies have identified individuals whose facial perception and memory systems are impaired. In 2008, Riddoch, Johnston, Bracewell, Boutsen & Humphreys detailed an important study of a woman with a very pure case of prosopagnosia. Her ability to perceive and remember non-face objects was completely intact, while she showed a total inability to process, learn about, categorize and remember facial stimuli. She had to rely on contextual and other environmental clues (e.g. clothing, hairstyle, voice) to determine whom familiar people were,
and had extreme difficulty recognizing people in unexpected situations. She could not recognize the faces of famous people with whom she was familiar, and performed at a chance level for an unfamiliar face memory task. Despite her poor facial memory performance, her memory for words and other non-face visual stimuli (even complex and multi-feature novel stimuli) was excellent. Her case is an important one because it provides concrete evidence for the hypothesis that the processes underlying facial perception and memory work independently of perceptual and memory processes for other simple and complex non-face stimuli. The inability to accurately perceive and remember faces would make forming new relationships and navigating everyday situations difficult without visual cues to guide interaction.

From a very early age, infants can recognize and preferentially focus their attention on faces (Morton & Johnson, 1991). The face and its features, especially the eyes, mouth and emotional expression (Benuzzi et al., 2007; Fox, Mathews, Calder & Yiend, 2007; Ganel, 2011; Lobmaier, Tiddeman & Perrett, 2008; Pecchinenda, Pes, Ferlazzo & Zoccolotti, 2008) have been shown to convey lots of information about the social environment. Several perceptual processes and associated brain regions are involved in observing the faces of others and interpreting context.

Haxby et al. (2000) reported that the processes underlying the perception of static facial features operate independently of the processes that underlie the perception of facial movements. The feature processing system (or “core” system) includes the inferior occipital gyrus, the superior temporal sulcus, and portions of the fusiform gyrus. The fusiform gyrus has been shown to perceive and represent whole faces and their permanent features (bone structure, general shape, relative distance between features). The superior temporal sulcus is involved in perceiving and forming representations of changeable aspects of the face (expression, eye gaze). The
movement processing system (the “extended” system) seems a bit more complex. The intraparietal sulcus, superior temporal gyrus, and the anterior temporal lobe are involved in different aspects of facial movement perception (Haxby et al., 2000).

Benuzzi et al. (2007) used functional magnetic resonance imaging (fMRI) to understand what brain regions are active when viewing faces as opposed to non-face items. They found the core system described by Haxby et al., (2000) to be significantly more active when viewing whole faces and partial faces (both upper and lower individually) as opposed to scrambled grayscale images. This provides further evidence that facial perception is a uniquely complex process.

Electrophysiological studies have also looked at facial perception in humans. Scalp electrodes over the posterior-lateral skull in an event-related potential (ERP) study detected a significant negative potential change in subjects approximately 170 msec after they were presented with images of unfamiliar human faces (Bentin, Allison, Puce, Perez & McCarthy, 1996). This potential change (N170) was not present when subjects viewed images of non-face items such as cars, hands, butterflies and animals. A large N170 was also observed in response to images of isolated eye regions, indicating that the eyes are a key component of facial perception. The selective presence of the N170 for faces and eyes suggests that a unique process is involved in the perception of faces as opposed to non-face items.

We have seen that facial perception is important for social interaction, and that many brain regions have been implicated. It has also been shown that whole faces are not necessary to evoke facial perception processes. Of all the different features and characteristics of the human face, one particular region seems to provide the most insight into the social environment.

The Eyes and Gaze
The eyes play a crucial role in expressing emotions, beliefs and desires, and are the most information-rich part of the face (Frischen, Bayliss & Tipper, 2007). From infancy, humans’ attention is preferentially directed toward the eye region of the face (Hoehl & Striano, 2008). The eyes of others draw the attention of observers (Emery, 2000) and provide a wealth of information to those around them.

What makes the eyes so informational, among other things, is their ability to show observers where a person’s attention is focused, and how they feel about what they see. The averted gaze of others guides an observer’s attention, and can be used with or without other bodily cues to signal the focus of joint social attention (Fox et al., 2007; Freeth, Ropar, Chapman & Mitchell, 2010; Laube, Kamphuis, Dicke & Thier, 2011). In social situations, the brain perceives these attentional cues and helps us figure out how to appropriately behave and interact. For example, if a group of friends is sitting in a room, one must use gaze cues to assess the situation and act accordingly. If the focus of social attention is the television, it is probably a bad idea to walk in front of it. On the other hand, if a group member finishes talking and shifts their gaze to someone else, it may be that person’s turn to speak.

Direct gaze (eye contact) seems to be a much more relevant stimulus than averted gaze for human perceptual processes. The ability to discriminate between direct and averted gaze develops at an early age. In an ERP study, infants younger than one year old showed greater arousal responses to angry faces with direct as opposed to averted gaze (Hoehl & Striano, 2008). Directly gazing eyes can signal a threat (especially for anxious individuals), and relay emotions such as fear and anger (Fox et al., 2007; Hoehl & Striano, 2008; Wieser, Pauli, Alpers, & Muhlberger, 2009). Direct gaze has also been found to be involved in danger, conflict and anxiety responses (Fox et al., 2007; Hadjikhani, Hoge, Snyder & Gelder, 2008; Hietanen,
Leppanen, Peltola, Linna-aho & Ruuhiala, 2008; Wieser et al., 2009). It is possible that perceived direct eye contact (especially with an angry or negative facial expression) is a signal of a potential threat, and leads to increased attention and vigilance of the observer. This would, in turn, lead to deeper processing, and perhaps better memory for the face.

Facial expressions and emotions, especially negative ones, impact the way people perceive and interpret the gaze of others. Research has explored how facial expressions such as fear and anger interact with gaze direction to produce behavioral and neurophysiological responses. Pecchinenda et al. (2008) found fearful and disgusted facial expressions with averted gaze significantly enhanced a directional attention shift in observers. Reaction time for a directional judgment was faster for the negative facial expressions than the positive. Fox et al. (2007) found similar results in anxious individuals when viewing fearful facial expressions with averted gaze. Their results showed that anxiety-prone people follow the averted gaze of fearful facial expressions faster than other expressions. In addition, the results revealed that anxiety-prone individuals have a tendency to fixate on and pay attention to faces displaying an angry expression with direct gaze longer than other expressions. These results seem to be similar to the Porter, Hood, Troscianko & Macrae (2006) findings that females display increased pupil dilation when viewing direct as opposed to averted gaze. Collectively, these reports seem to indicate that direct eye contact holds the attention of the observer, while averted gaze directs attention in the direction of the averted gaze.

Hadjikhani, Hoge, Snyder & Gelder (2008) investigated the neuroanatomical basis for processing fearful facial expressions of others. Using fMRI, they found that fearful faces with averted gazes produce elevated activation in areas related to gaze shifting, (superior temporal
sulcus, intraparietal sulcus), and areas related to fear-processing (amygdala, hypothalamus, pallidum), as well as areas involved in motion detection.

With fear and negative emotion playing a role in gaze and face perception, it is important to discuss the main structure involved in emotion and fear processing: the amygdala. Benuzzi et al. (2007) found that the amygdala is involved in scanning and orienting attention to the most socially relevant part of the face, the eyes. This may provide evidence that gaze is indeed a key component for conveying fear and environmental threats. The Hadjikhani et al. (2008) study supports the Benuzzi et al. (2007) claim that the amygdala is involved in attention shifting toward the eyes. They found the amygdala and other fear-processing areas to be active along with areas related to gaze shifting when viewing the averted gaze of fearful faces. The amygdala seems to be a key player in humans’ attentional shift in response to emotional expressions and gaze direction.

Although fear and danger appear to be the most evolutionarily important information conveyed by eye gaze, they may not be the most socially relevant in today’s society. Gaze has also been found to influence judgments of qualities such as personality and trustworthiness. Faces whose gaze matches the direction of a target stimulus were judged to be more trustworthy than faces whose gaze was in the opposite direction of the target stimuli (Bayliss & Tipper, 2006). Burton, Bindemann, Langton, Schweinberger & Jenkins (2009) found that in order to perceive and process the gaze of another person, attention must be focused on that person. They examined this using an interference task, where subjects reported the direction of a target stimulus (a hand or a gazing face) while also presented with a distractor (another hand or gazing face). The results showed an interference effect for distractor hands, but not for distractor gazing faces. Gazing faces outside the focus of attention are not able to be fully perceived and
processed. In order to perceive a face and its gaze, it is necessary for attention to be completely focused on that face.

The perception of faces and their gaze is an intriguing phenomenon, and plays a role in modulating people’s memory for unfamiliar faces.

**Recognition Memory for Faces**

Although face perception occurs fairly rapidly (Bentin et al., 1996), encoding a face into memory is a more complex process. Once a face and its gaze have been perceived, the brain must either decide to encode the face into memory or forget about it. It turns out that the brain has many preferences and biases for remembering or forgetting certain faces. How people recognize, recall and remember familiar and unfamiliar faces is the subject of much research and intrigue.

When testing peoples’ recognition memory for faces, experimenters must ensure that their subjects process the faces deeply enough to encode them into memory (Burton et al., 2009). In order to accomplish this, it is common for experiments to contain some sort of judgment or decision task during study to encourage subjects to pay full attention to the stimuli. Decisions range from personality judgments, such as trustworthiness or likability, to judgments of age, gender, profession, hobbies, intelligence, and religious or political preferences. Research has found that judgments about more abstract characteristics of a face seem to be related to better memory for that face (Coin and Tiberghien, 1997).

Gender, a major aspect of social interaction, is one variable known to modulate humans’ ability to remember faces. In addition to the Porter, Hood, Troscianko & Macrae (2006) findings that females display increased pupil dilation when viewing direct as opposed to averted gaze,
Vuilleumier, George, Lister, Armony & Driver (2005) found recognition memory to be enhanced for faces of the opposite gender, after making gender judgments during study.

Race has also been identified as a variable known to have a significant effect on peoples’ ability to distinguish between, recognize and remember faces. Research has found that people have more difficulty discriminating between and remembering faces from races outside their own. This is known as the cross-race memory effect (Adams, Pauker & Weisbuch, 2010). Valentine & Bruce (1986) found that recognizing faces of other races was more difficult than recognizing own-race faces when the faces were inverted at test. This research suggests that own-race faces are more familiar and more easily distinguished from each other than other-race faces.

Neural correlates for facial memory have been identified via ERP and fMRI studies. There is support for a dual-process theory of recognition memory for faces. Curran & Hancock (2007) looked at ERP correlates for humans’ facial recognition memory, and found two distinct components that relate to two separate parts of the recognition memory process. One potential difference across the frontal region of the skull corresponds with a familiarity component of memory, and occurs roughly 400ms after stimulus presentation (FN400). This relates to times when a face seems familiar to someone, but they can’t remember a name, any details about the person, or where they know the person from. The other potential difference occurs in the parietal region of the skull approximately 500-800ms after stimulus presentation. This component signals recollection of the face, and corresponds to someone remembering details about faces, or specific situational cues. Hofer et al. (2007) used fMRI to find out what specific brain structures, regions and nuclei are involved in recognition memory for unfamiliar faces. They found activation in
many different regions across the frontal, occipital and parietal lobes to structures such as the cerebellum and thalamus.

The aim of the present study is to address the interaction between gaze direction and recognition memory for faces. Previous behavioral experiments have looked at gaze direction’s effect on memory, and have mostly found directly gazing faces (faces making eye contact with the observer) to be associated with more accurate recognition memory than faces with averted gaze (looking to the side, not making eye contact). This study will attempt to replicate these experiments, incorporating aspects of each.

**Effect of Gaze Direction on Facial Recognition Memory**

As has been detailed previously, most studies have found direct gaze to be advantageous for facial processing and reaction time, but averted gaze has been implicated in speeding an observer’s attentional shift. Numerous studies have demonstrated direct over averted gaze advantages for reaction time, recognition memory accuracy and gaze fixation time for children and adults (Farroni, Massaccesi, Menon & Johnson, 2007; Hood, Macrae, Cole-Davies & Dias, 2003; Mason, Hood & Macrae, 2004; Smith, Hood & Hector, 2006). These studies used various different techniques and variables to examine their interaction with gaze direction and their effect on recognition memory for faces, but overwhelmingly the results show that directly gazing faces seem to have memory, fixation and reaction time advantages over faces with averted gaze.

The present study aimed at further investigating the effect of gaze on people’s recognition memory for unfamiliar faces. Two related experiments were used to further address how gaze direction interacts with other variables to produce significant memory effects or advantages. Both examined how memory is affected by gaze direction (direct vs. averted). Additionally, the present experiments took into account the fact that there are two distinct parts
to memory: encoding and retrieval. Encoding refers to the process of putting the faces into memory (learning or studying), and retrieval refers to the process of pulling those faces from memory (remembering). Gaze can be manipulated during encoding or retrieval (i.e. during the study phase or the test phase). In the present study, when subjects completed the encoding manipulation condition, they saw faces with direct or averted gaze during study, and faces with eyes closed at test. Conversely, when subjects completed the retrieval manipulation condition, they saw faces with eyes closed during study, and faces with direct or averted gaze at test.

The gaze manipulation conditions (encoding vs. retrieval) and the order in which the subjects completed these two conditions were two essential components of the present study. The only other studies to address the gaze manipulation condition variable were Hood et al. (2003) and Smith et al. (2006). Both looked at the encoding manipulation condition and the retrieval manipulation condition. Smith et al. (2006) randomly assigned subjects to complete only one of the gaze manipulation conditions (a between-subjects manipulation). Hood et al. (2003) also investigated memory differences between the two gaze manipulation conditions, but instead had each subject complete one block of each condition (a within-subjects manipulation), and the order of the blocks was counterbalanced across all subjects.

The within-subjects design allows for more direct comparison of gaze effects, because individual differences are held constant (and thus cancel out) when one subject completes both blocks. Between-subject designs leave room for individual differences to affect the results for that particular variable. Although Hood et al. (2003) utilized the within-subjects design, they neglected to examine whether or not the order in which a subject completes the two separate conditions (encoding first or retrieval first) has an effect on gaze direction’s role in recognition memory.
Like Hood et al. (2003), the present study also utilized a within-subjects design for the gaze manipulation variable, but took the possible effect of block order into consideration between subjects as well. With only limited research into the effects of the gaze manipulation condition, and seemingly none on block order’s effects, this study hoped to provide new insight into how learning and remembering faces is affected by eye gaze.

Experiment 1 addressed the two separate gaze manipulation conditions. In one, gaze was manipulated during study (encoding), and in the other, gaze was manipulated during test (retrieval). To eliminate any possibility of pattern matching or other gaze effects confounding the experiment, all faces were presented with eyes closed during the phase at which gaze was not manipulated. All subjects in Experiment 1 completed two separate blocks of the experiment: one block of the encoding manipulation condition, and one block of the retrieval manipulation condition. The order in which subjects completed the conditions was counterbalanced, so half completed the encoding manipulation condition first, and half completed the retrieval manipulation first. This allowed for analysis of the differences between the half of the subjects who completed the encoding manipulation condition first, and the half who completed the retrieval manipulation condition first.

The present study utilized an old/new paradigm, in which subjects made a decision about whether each face presented during test is old (previously seen during study) or new (not seen during study). The use of an old/new memory paradigm allows for more advanced analysis of subjects’ memory tendencies and abilities than simply examining their accuracy performance for the memory test (hit rate).

In order to find significant memory advantages, it is important that subjects’ memory performance is well above chance. Thus, ensuring that subjects were able to correctly identify
which faces they had already seen and which they had not was a key emphasis when designing
the experiment. Several design components were included to increase accuracy and encourage
deeper processing of the face stimuli. Subjects completed an age judgment task during study to
ensure that attention was fully focused on the face (Burton et al., 2009). Subjects were also
required to view all of the faces in the study portion of the experiment three times to help
increase their memory of the target faces. The faces were presented for three seconds each,
allowing plenty of time to perceive and commit the faces to memory.

Based on the previous research discussed above, the general hypothesis was that direct
gaze would continue to display a memory advantage over averted gaze. As far as the gaze
manipulation variable is concerned, the hypothesis was less certain. Hood et al. (2003) and Smith
et al. (2006) found inconclusive results when analyzing the effect of gaze manipulation
condition. One study found direct gaze’s advantage over averted gaze to be a bit more
pronounced in the encoding manipulation condition (Smith et al., 2006), but this effect only
approached significance. The other study did show a significant interaction between gaze
direction and gaze manipulation condition, but declined to report which condition corresponded
to the more pronounced gaze direction effects (Hood et al., 2003). Looking at the results of this
study, it seems that the encoding manipulation condition also showed a more distinct advantage
for direct over averted gaze than the retrieval manipulation condition. Based on these limited
conclusions, it was predicted that the gaze direction advantage for direct gaze would be more
pronounced during the encoding manipulation condition than the retrieval manipulation
condition.

Without previous research on which to base a hypothesis for the effect of the order that
subjects complete the blocks, prediction is difficult. Because the encoding manipulation
condition was loosely shown to correspond to stronger gaze effects, the prediction was that subjects who completed the encoding manipulation block first would also display stronger memory effects than those who completed the retrieval manipulation block first.

**Experiment 1**

**Method**

**Subjects**

Subjects were recruited from General Psychology classes at the University of Colorado at Boulder. General Psychology students were required to participate in experiments to receive credit for the course. In total, 25 undergraduates, aged 18-21, completed the experiment (22 female, 3 male). All subjects completed the experiment successfully, and none of the data were excluded from analysis.

**Materials**

Face stimuli were taken from the color FERET database of photographs (Phillips, Moon, Rivzi & Rauss, 2000). All face stimuli were transformed to a digital image using FaceGen software. This was done in order to manipulate gaze direction for a given face. Hair was removed, and faces were displayed from the neck up. In total, 68 total faces were converted to stimuli using the software. Faces with glasses were excluded due to the FaceGen software’s inability to convert them to a manipulable digital image. The stimuli set was comprised of 34 male faces and 34 female faces which were representative of various races and ethnicities. The removal of hair during stimuli creation caused many of the originally female faces to appear more masculine. Race salience was also affected, as the original faces (individuals of many different races) generally tended to appear more mixed-race after conversion. Faces were
converted to grayscale, and brightness and contrast were enhanced using Adobe Photoshop. Four versions of each face were created: closed eyes, direct gaze, gaze averted left and gaze averted right (see Figure 1).

**Figure 1.** Two of the faces used in Experiments 1 and 2. Four stimuli were created from each face: direct gaze, closed eyes, averted right and averted left.

Stimuli were presented to subjects on an Apple iMac computer against a black background. All stimuli were 400 x 400 pixels in size with a screen resolution of 1024 x 768 pixels. Subjects were positioned 100 cm from the screen during the experiment. Eight of the stimuli were used as buffers, to guard against serial position effects identified by Deese and Kaufman (1957). This study revealed that people most often remembered the last and first items of a list compared to items in the middle of the list. These are known as primacy and recency effects. Each buffer image was used as either a primacy or recency buffer for each subjects’ study phase. These faces were presented to subjects at the beginning or end of each study list but were not tested.

**Design**
Three independent variables were manipulated during the experiment: gaze direction (direct or averted), the phase at which gaze was manipulated (encoding or retrieval), and the order that the subjects completed each phase (encoding first or retrieval first). Gaze direction and gaze manipulation phase were variables manipulated within subjects, because each subject saw both direct and averted gazes, and each completed both the encoding and retrieval conditions. This allowed for comparison between a subject’s accuracy for both levels of each condition, and individual differences between subjects are held constant from trial to trial. However, phase order was manipulated between subjects because each subject did not complete both levels. Therefore, results for the phase order variable could only be compared between different subjects. The dependent variable measured was accuracy for the old/new response during each test phase.

Stimuli were counterbalanced across all subjects for gaze direction and gaze manipulation phase. Each face was used an equal number of times in all four gaze conditions (closed, direct, averted left, averted right) across subjects, but was only used once for each individual subject. Each face was used an equal number of times as a target and distractor face in both of the gaze manipulation conditions (encoding and retrieval), but again was used only once for each subject. This was done to control for any individual stimulus being more memorable than the others.

Procedure

Before beginning, subjects were informed that they would be taking part in a memory experiment. They then completed a study phase with three separate parts followed by a test phase. The three parts of the study phase each included the same faces with the same gaze direction, except the order of the stimuli were re-randomized each time through. The three
repetitions of each face were intended to increase accuracy. Each of the three parts of the study phase began with two primacy buffers followed by the 20 target stimuli and finally two recency buffers. Every study face was presented for three seconds with a one second inter-stimulus interval. These times were chosen based on previous experiments (Hood, Macrae, Cole-Davies & Dias, 2003; Mason, Hood & Macrae, 2004; Smith, Hood & Hector, 2006), and on pilot study data acquired prior to this experiment.

Subjects were instructed to make an age assessment for each face during study. They were told to decide whether the current face appeared to be older or younger than the face presented before it, and indicate their judgment by pressing one of two keys on a keyboard. Subjects were told not to make a judgment for the first face, because there was no previous face for comparison. The judgment task was designed to encourage deeper processing of the stimuli during study. Mason et al. (2004) used a similar encoding task, asking their subjects to make an over/under 21 years old judgment for each face at study. However, many of the present faces appeared to be older, so the task was modified accordingly.

Upon completion of each time through the study list, subjects were instructed to take as long as they needed to rest their eyes, and to continue on to the next round when ready. After completing all three parts of the study phase, subjects were instructed to sit quietly and wait for instructions after a two-minute break. The break was included to allow the most recently viewed faces to fade from working memory. This ensured that all memory effects observed during test were the result of long-term memory processes. After the break, subjects began the test phase. They were tested on their memory for the 20 previously studied faces (not including the buffer faces), with 10 new distractor faces randomly intermixed. Subjects were given five seconds to make an old/new judgment about each face by pressing one of two keys on a keyboard. The test
face disappeared when judgment was made. Once all 30 judgments were recorded, the subjects moved on to the second condition of the experiment, which had the same structure and format as the first.

The two different conditions represented the two different levels of the gaze manipulation phase variable (at encoding vs. at retrieval). Subjects completed one block of each condition, and the order of the conditions was counterbalanced across all subjects. The two conditions differed in the phase at which gaze direction was manipulated. Gaze was manipulated during the study phase for the encoding condition, and during the test phase for the retrieval condition. Encoding refers to the process of putting information into memory during the study phase, and retrieval refers to the process of pulling information from memory during the test phase.

During the phase that gaze was manipulated, the faces displayed either direct gaze (staring directly at the subject), or averted gaze (eyes pointing either left or right with the head in the same position). Stimuli with averted gaze were equally split between averted left and averted right. When gaze was not manipulated, faces were shown with eyes closed to control for undesired gaze effects. Subjects were informed prior to the test block that the eyes of the stimuli would change (open to closed and vice-versa), but were instructed to judge whether they had seen the same face during the study phase regardless of the eye change.

To illustrate, if a subject’s first block was the encoding manipulation condition, they would view two primacy buffers (one averted, one direct in random order), 20 target faces (five averted left, five averted right and 10 direct; randomly intermixed), and two recency buffers (again one averted, one direct in random order), making an older/younger judgment for every face except the first. This would be repeated three times, each in a new random order. After a two-minute break, the subjects would then view 30 test faces (the 20 target faces and 10
distractor faces) in random order, all with eyes closed. The participant would make the old/new judgment for each face. They would then complete the retrieval manipulation condition of the experiment, which would have the same structure as the first block. The only difference would be that the faces in the study phase would have eyes closed, and the faces in the test phase would display either direct or averted gazes (see Figure 2).

The entire experiment lasted approximately 25 minutes, and then subjects were debriefed, given a feedback sheet to keep, and thanked for their time.
Figure 2. Short example study and test blocks for both the encoding and retrieval gaze manipulation conditions from experiment 1. Actual study and test phases contained 24 and 30 faces, respectively.
Results

The raw dependent variable measured was subjects’ response accuracy for the old and new items. Because this experiment involved testing subjects’ memory for recently studied items in an old/new paradigm, it is important to discuss signal detection theory (SDT). SDT is a prominent way of interpreting how people make decisions based on memory. It goes beyond simply analyzing response accuracy, allowing for determination of a person’s bias toward making one type of response or another, and their sensitivity for discriminating different types of stimuli (i.e. old vs. new). As an extreme example, a person who has a bias to always respond “old” will have 100% accuracy on studied items and 0% accuracy on the non-studied items. In order to correct for such biases, it is necessary to look at four different possible responses a subject could give for a test item. If the item has been previously studied (an “old” item), the subject can either correctly identify it as old (a “hit”), or can incorrectly identify it as a new item (a “miss”). If the test item has not been previously studied (a “new” item), the subject can either correctly identify it as new (a “correct rejection”), or can incorrectly identify it as old (a “false alarm”).

Neath & Surprenant (2003) describe SDT and several variables used to represent response tendencies and discrimination ability. One of these variables is called d’ (d-prime). This tells about a subject’s ability to discriminate between old stimuli and new ones. When a subject studies a face (or when someone encounters a face in a real-life interaction), there should be some corresponding amount of memory strength for having previously seen that face. When tested, old faces should signal a stronger memory response than should new faces. The d’ measure is a way of representing a subject’s overall ability in discriminating between faces they saw during study (signal present) from the strength of memory they have for faces they did not
see during study (signal absent). In terms of subjects’ memory strength responses, there should be a separate normal distribution for old faces and new ones. The d’ measure is a representation of the distance between the means of these two normal distributions (i.e. the subject’s ability to detect the difference in memory strength for old and new faces). The difference between the means for the two distributions corresponds to the difference in memory strength of the two groups being compared (in this case, old and new). The larger the d’ value, the better the subject is at discriminating between old and new. A d’ value approaching zero indicates poor discrimination ability where subjects cannot tell the difference between old and new faces, and thus near-chance (or guessing) performance. If gaze direction does have an effect on people’s memory discrimination ability for direct versus averted gaze, we expect to see significantly different d’ values for each condition. In terms of d’, the hypothesis is that direct gaze will lead to better discriminability between old and new faces than averted gaze.

A 2 (gaze direction: direct or averted; within subjects) X 2 (gaze manipulation phase: encoding or retrieval; within subjects) X 2 (order: encoding 1st or retrieval 1st; between subjects) analysis of variance (ANOVA) was performed for Experiment 1. For the d’ measure, there was a significant interaction between gaze direction and order of manipulation conditions, F(1, 23) = 3.42, p = .004; as well as a significant interaction between gaze direction, gaze manipulation phase, and order, F(1, 23) = 5.90, p = .001. No other main effects or interactions approached significance. To understand the 3-way interaction, planned comparisons were used to examine the gaze direction effect within each condition separately (see Figure 3). When gaze direction was manipulated during encoding, d’ was larger for direct than averted gaze when encoding was first, t(12) = 2.59, p = .02; but direct and averted case did not differ when encoding was second, t(11) = 1.24, p = .24. When gaze direction was manipulated during retrieval, d’ was larger for
direct than averted gaze when retrieval was first, \(t(11) = 2.72, p = .02\); but \(d'\) was larger for averted than direct gaze when retrieval was second, \(t(12) = 2.81, p = .02\).

**Figure 3**

Chart of \(d'\) values for 3-way interaction between gaze direction, gaze manipulation phase and order of manipulation conditions.

<table>
<thead>
<tr>
<th>(d') value</th>
<th>Encoding</th>
<th>Retrieval</th>
<th>Encoding</th>
<th>Retrieval</th>
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**Experiment 2**

**Method**

After analyzing the results of Experiment 1 it was decided to investigate whether subjects’ accuracy and responses differed from the first block to the second, without changing the gaze manipulation phase variable. Experiment 2 examines whether the order that the subjects complete the blocks has any effect on memory accuracy or any interaction with the gaze direction variable. In Experiment 2, subjects completed virtually the same procedure as Experiment 1, but they completed two blocks of the same gaze manipulation condition (encoding or retrieval) rather than one block of each condition. This allowed for comparison between the first block and the second without interference from the gaze manipulation phase change. The gaze manipulation condition variable was now manipulated between subjects like the Smith et al.
(2006) study, because each subject now only completed one of the two gaze manipulation conditions rather than both.

Subjects

Subjects were again recruited from General Psychology classes at the University of Colorado at Boulder. 26 undergraduate participants aged 18-21 completed the experiment (16 female, 10 male). All participants completed the experiment successfully, and none of the data were excluded from analysis.

Materials

Again, face stimuli were taken from the color FERET database of photographs (Phillips et al., 2000). The same computer-generated stimuli used in Experiment 1 were used in this experiment. 400 x 400 pixel stimuli were again presented on an Apple iMac computer with a black background with 1024 x 768 pixel screen resolution. Subjects again were 100 cm from the screen during the experiment.

Design

Two previous independent variables were manipulated in this experiment: gaze direction and gaze manipulation phase, in addition to the new block number variable. The gaze manipulation variable was manipulated between subjects in Experiment 2 rather than within subjects as in Experiment 1. This is because each subject completed two separate blocks of the same condition (either encoding or retrieval), rather than one of each. Once again, the dependent variable measured was accuracy for the old/new response during the test block, which was converted to d’ for statistical analysis.

Procedure
Experiment timing, list length, stimuli, and counterbalancing were kept the same. Subjects were again informed that they would be completing a memory task, and that the eyes would be different in the test block than they were in the study block. Subjects completed three rounds of the study lists and then were tested on the 20 target stimuli and 10 distractor faces. They again made the age judgment (older/younger) each time through the study block, and made the old/new judgment during the test block. This time, however, subjects completed an additional phase of the condition they were assigned (either encoding or retrieval). All 68 faces were still used for each subject, and no face was used twice for any given subject. This experiment again lasted approximately 25 minutes, and subjects were debriefed, given a feedback sheet to keep, and thanked for their time.

Results

For Experiment 2, similar statistical tests were performed as in Experiment 1. A 2 (gaze direction: averted or direct; within subjects) X 2 (gaze manipulation phase: encoding or retrieval; between subjects) X 2 (block number: 1 or 2; within subjects) ANOVA was performed. There were no significant interactions between any of the variables for the d' measure (see Figure 4), including those corresponding to the significant effects observed in Experiment 1. The interaction between gaze direction and block number was not significant, F(1, 24) = .182, p = .40. The three-way interaction between gaze direction, block number and gaze manipulation phase was also not significant, F(1, 24) = .040, p = .69. None of the planned comparisons on the gaze direction effect within each condition were significant. No discrimination advantages were found for any condition in Experiment 2.
First Block Results from Experiments 1 and 2 Combined

After analyzing the results from Experiment 1 and Experiment 2, some discrepancies were noticed. Because the procedure was nearly exactly the same between the two experiments, it would be expected that performance for a subjects’ first block should be similar across the two experiments. Subjects whose first block was the encoding condition in Experiment 1 should have similar results to those subjects whose first block was the encoding condition in Experiment 2, as they completed exactly the same task. The same goes for the accuracy of subjects’ first blocks for the retrieval condition in each experiment. However, significant interactions were seen for Experiment 1, but not Experiment 2, creating questions about the differences between the two experiments. The decision was made to combine the first block data from both experiments, and do an overall statistical analysis to determine if the experiment variable interacts with any other variables. This ANOVA had a 2 (experiment: 1 or 2; between subjects) X 2 (eyes: averted or direct; within subjects) X 2 (phase: encoding or retrieval; between subjects) design. When
analyzing all subjects’ first blocks from both experiments, two significant effects/interactions were found (see Figure 5). Discrimination (d’) was significantly higher for direct than averted eyes, F(1, 47) = 3.48, p = .002. There was also a significant interaction between experiment and eyes, F(1, 47) = 1.54, p = .04; indicating that the block 1 advantage for direct over averted eyes was larger in Experiment 1 than Experiment 2. Contrary to previous indications that gaze effects might be larger during encoding than retrieval (Hood et al., 2003; Smith et al., 2006), we did not observe any interaction between gaze manipulation phase and eye gaze, F(1, 47) = 0.83, p = .367.

**Figure 5**
Chart of overall d’ values for interaction between gaze direction, gaze manipulation phase and Experiment during all subjects’ first block.

**Discussion**

The main aim of this study was to examine the role that gaze direction plays in people’s recognition memory for faces. Based on the results of several previous studies, the hypothesis was that directly gazing faces would lead to better memory discrimination ability than faces with
averted gaze. The present study also sought to look at the effect of the phase at which gaze was manipulated (encoding or retrieval), and whether or not the order that subjects completed these two conditions had an effect on memory performance. Few previous studies have looked at similar effects, but the encoding manipulation condition has been associated with slightly better performance than the retrieval manipulation condition (Hood et al., 2003; Smith et al., 2006). Therefore, it was expected that similar advantages would be present for the encoding manipulation condition in the current study. Overall, the present results were consistent with these hypotheses, but the expected advantages of direct gaze were not reliably observed in each and every condition.

The first analysis of Experiment 1 was performed to determine if there were any interactions between gaze direction (direct or averted), gaze manipulation phase (encoding or retrieval), and the order the subjects completed the blocks (encoding first or retrieval first). The significant three-way interaction between all the variables provides us the most information about Experiment 1. Examining the planned comparisons for each one of the higher-order interactions (see Figure 3) revealed how subjects’ memory discrimination ability differed from condition to condition. In support of previous research, direct gaze displayed a memory discrimination advantage overall in subjects’ first block, regardless of whether it was the encoding manipulation condition or the retrieval manipulation condition. Direct gaze lead to better discrimination ability than averted for the encoding manipulation block of the subjects who completed the encoding block first, and for the retrieval manipulation block of the subjects who completed the retrieval block first.

For subjects’ second block, however, the analysis of the data showed less predictable results. For those subjects who completed the retrieval manipulation condition first, no
significant advantage was present for direct or averted gaze during the encoding manipulation phase. However, for those subjects who completed the encoding manipulation condition first, averted gaze actually displayed a significant memory advantage over direct gaze during the retrieval manipulation block. This is in direct contradiction with Hood et al. (2003) and Smith et al. (2006), who also looked at gaze manipulation phase effects and did not identify any advantages for averted gaze over direct.

A closer look at previous research is needed to help explain the advantage for averted gaze over direct found in Experiment 1. At least one study has found a case of averted gaze having a significant advantage over direct gaze for human facial memory. Vuilleumier et al. (2005) found direct gaze to provide a memory advantage over averted for the majority of the conditions they examined, but one particular analysis showed an advantage for averted over direct. When examining the hit rate for faces of the opposite gender that subjects had previously studied, faces displaying averted gaze during study actually showed a significant memory advantage over directly gazing faces when presented straight on as opposed to in a ¾ view. The subjects in the study were 11 males and 11 females, and this was found to be an overall effect (observed for both male and female subjects). This provides room for the suggestion that humans remember faces of the other gender better when observing the faces straight on without making eye contact. Viewing a face with direct gaze provides us with a connection to that person and leads to increased arousal (Nichols & Champness, 1971), while viewing a face with averted gaze may allow for more passive observation of the features without the social interaction processes coming into play.

The results of Experiment 1 raised further questions regarding whether there was a significant difference between subjects’ performance in the first and second blocks. With
subjects completing two consecutive blocks of the same condition in Experiment 2 rather than switching conditions halfway through, direct comparison of first and second block effects was possible without interference from gaze manipulation phase change.

However, upon conducting similar statistical analyses as in Experiment 1, none of the conditions (gaze direction, gaze manipulation phase, block number) produced a significant effect or advantage for either direct or averted gaze. This is especially unexpected because the first block of Experiment 1 and the first block of Experiment 2 are essentially the exact same experiment, except for the gaze manipulation condition variable. In other words, that half of the subjects whose first block was the encoding gaze manipulation condition (regardless of which experiment they participated in) performed exactly the same task during this block, and should have, in theory, produced similar results. The same can be said for the other half of the subjects whose first block was the retrieval gaze manipulation condition in each experiment. The fact that three significant memory advantages were identified for separate conditions in Experiment 1, yet no significance was present in Experiment 2 indicates that the two experiments differed in their memory effects.

To determine exactly how the results of the two experiments differed and to look for overall gaze effects, the data gathered from each subject’s first block was compiled and analyzed. Analysis revealed the combined data were supportive of previous studies, and did show an overall advantage for direct over averted gaze. Despite the absence of a significant advantage for either gaze direction in Experiment 2, and the advantage that averted gaze displayed over direct in subjects’ second block for subjects who completed the encoding manipulation condition first in Experiment 1, the combined results confirmed the overall
findings of the majority of previous research on gaze direction’s modulation of facial memory (Hood et al., 2003; Mason et al., 2004; Smith et al., 2006, Vuilleumier et al., 2005).

This analysis also revealed that the second main variable in the two present experiments, gaze manipulation phase, failed to produce any significant overall advantages for either the encoding or retrieval condition. Unlike Hood et al. (2003) and Smith et al. (2006), who identified tendencies for the encoding manipulation condition to be associated with stronger gaze effects than the retrieval manipulation phase, the present study failed to produce any significant effects or interactions for the gaze manipulation phase variable.

In addition to direct gaze’s overall advantage over averted gaze, the results showed that the memory advantage for direct over averted gaze in subjects’ first block was significantly greater in Experiment 1 than Experiment 2. The reason for this result is less clearly explained by previous literature. As mentioned in the introduction, the only other studies to examine the gaze manipulation condition (Hood et al., 2003; Smith et al., 2006) found that direct gaze lead to better memory for faces in both the encoding and retrieval manipulation conditions. The data acquired in the present study seem to suggest that having subjects complete both conditions in separate blocks rather than two blocks of the same condition causes more pronounced gaze memory effects. However, this cannot be the full explanation because analysis of both experiments’ first block (which were exactly the same in terms of procedure) revealed a significant difference between the two. The fact that subjects then went on to complete either a block of the other gaze manipulation condition (Experiment 1) or another block of the same condition (Experiment 2) would not have an effect on the first block results, because subjects were not aware of their task for the second block.
One possible reason for the difference between the two experiments is a variable previously shown to have a significant impact on gaze perception and facial memory: Gender. Experiment 1 had a much higher female-to-male ratio (22:3) than Experiment 2 (16:10). The fact that Experiment 2 had more gender balance than Experiment 1 may help to explain the difference in results. The faces in the current study were presented to subjects without hair, and converting them to digital images caused most stimuli to have a more masculine than feminine appearance. Therefore, Experiment 1 may have had a larger representation of cross-gender facial perception and memory than same-gender encounters between subjects and stimuli. Based on the averted gaze advantage found by Vuilleumier et al. (2005) when subjects encoded opposite gender faces, we might expect Experiment 1 to show a more significant advantage for averted gaze than Experiment 2 (especially during the encoding manipulation), based on the higher proportion of female subjects viewing masculine faces. In the present study, this is actually the case for the retrieval manipulation, as the averted advantage found for second-block retrieval condition was present only in Experiment 1 and not Experiment 2. However, other advantages for direct over averted gaze were still identified in Experiment 1. Along these same lines, we may have expected the direct gaze advantage to be greater in Experiment 2. The higher proportion of male subjects should have meant that there were fewer cases where the stimuli were the opposite gender of the subject. However, no significant effects were found for Experiment 2, opening the door for further examination of gaze’s role in human recognition memory for faces.

Statistical analyses were performed for each experiment to include gender as a possible variable. With such a small male subject population for Experiment 1, a female-only analysis was performed to see if this changed the results. The same significant interactions were shown to
be present for the female subjects, and no new effects or interactions were revealed. However, removing the three male subjects did increase the significance of the two significant interactions just slightly. Due to the fact that Experiment 2 had a more balanced gender distribution for subjects, gender was included as a between subjects measure in the ANOVA. However, the addition of the gender variable still failed to produce any significant effects or interactions, indicating that gender did not seem to play a significant role in this study. This is unexpected, with previous findings suggesting gender to be implicated in modulation of facial gaze perception and memory.

Another variable that has been identified to play a role in facial memory and gaze that may have had an effect on the results on the present study is race. As detailed previously, faces from the same race as the observer are more accurately remembered than other-race faces. Nearly all the subjects in the present study were Caucasian, and the stimuli faces comprised many different races, making it possible for race effects to come into play. However, analysis including a race variable would have been difficult, due to the somewhat ambiguous racial identities of the digital stimuli faces.

A big limitation of the present study came from the stimuli used. The artificially generated faces were great for manipulating gaze direction, but they provided some limitations in terms of the variables that could be manipulated and the analyses that could be performed. Based on the literature discussed in the introduction, it is clear that variables like gender, facial expression and emotion modulate facial gaze memory and perception. As discussed before, the software-generated faces took on mostly masculine appearances and were presented without hair. This made cross- and same-gender analyses difficult, and the limited gender analysis that was performed failed to produce any additional significant effects. It is also possible that the
artificially generated stimuli failed to produce some gaze effects within subjects that actual face photographs would reveal. However, Experiment 1 and Experiment 2 still differed in their block 1 results but contained the exact same face stimuli, so this possibility seems unlikely.

There is still the need for further research on and clarification of gaze’s role in people’s recognition memory for faces. Emotional facial expressions have been highly implicated in affecting the way people perceive and interpret faces and gaze direction, and it would be very beneficial to include an emotion variable in future studies on gaze direction’s role in recognition memory for faces. Because emotional expressions indicating an avoidance response (i.e. fear) are associated with guiding social attention through averted gaze and expressions that indicate an approach response (i.e. anger) are associated with holding the attention of the observer with direct gaze (Hietanen et al., 2008), examining the effect of emotional expression on gaze direction and recognition memory for faces may provide interesting and relevant results in terms of face memory in different social interactions.

As discussed previously, gender and race are other variables that have been shown to have an effect on people’s ability to perceive, judge, classify and remember faces. Including these as variables in future studies and examining the relationship of gender and race with gaze direction and memory for emotionally expressive faces may provide further insight into exactly how human facial recognition memory works.

In order to include all these variables in a future study, it may be necessary to compile a large stimuli database with hundreds of real-face photographs including various views of each face. To look at all the relevant variables together, it would be necessary to have each face presented in many different views: all different emotional expressions with both direct and averted gaze, and with eyes closed.
The overall conclusion to be drawn from this study’s findings is that faces displaying direct gaze do indeed tend to lead to stronger memory accuracy and discrimination ability than faces with averted gaze, but this is not always the case. More research is needed, however, to determine exactly which variables affect humans’ preference for direct over averted gaze, and how variables like gender, race and facial expression combine to produce gaze memory effects. It also seems worthwhile to address when and why less-expected advantages are sometimes seen for averted gaze over direct gaze in terms of facial recognition memory. As discussed in the introduction, gaze perception and facial recognition memory are two very important aspects of human social interaction. The eyes of others give us a huge amount of information about the surrounding environment, and it is useful to see how different types of gazing faces affect our attention, behavior and memory. Research has shown that variables like emotional expression, race, and gender are important for understanding how people perceive faces and direct their attention accordingly. Finding out how these variables interact with the most socially relevant part of the face (the eyes) and how that affects people’s memory for faces can give us further insight into the dynamics of social interaction and learning.

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References


