Some effects of alcohol and eye movements on cross-race face learning

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Abstract

This study examines the impact of acute alcohol intoxication on visual scanning in cross-race face learning. The eye movements of a group of white British participants were recorded as they encoded a series of own-and different-race faces, under alcohol and placebo conditions. Intoxication reduced the rate and extent of visual scanning during face encoding, reorienting the focus of foveal attention away from the eyes and toward the nose. Differences in encoding eye movements also varied between own- and different-race face conditions as a function of alcohol. Fixations to both face types were more lingering and less numerous following during intoxication, but in the placebo condition this was only the case for different-race faces. While reducing visual scanning, however, alcohol intoxication had no adverse effect on face learning, only encoding restrictions associated with different-race face processing led to poorer face recognition. Results therefore support perceptual expertise accounts of own-race face processing but suggest the adverse effects of alcohol on face learning published previously (Dysart et al., 2002; Hilliar et al., 2010) are not caused by restrictions to foveal encoding.

Keywords: Alcohol intoxication, eye movements, face recognition, own race bias

Alcohol is the oldest and most widely used recreational drug yet its effect on our ability to perceive and remember faces has been examined in only four papers (Dysart, Lindsay,

MacDonald, & Wicke, 2002; Hagsand, Roos-af-Hjelmsäter, Granhag, Fahlke, & Söderpalm-Gordh, 2013; Hilliar, Kemp & Denson, 2010; Yuille & Tollestrup, 1990). Three of these exposed participants to a single target face for identification following retention periods ranging from minutes to days and found no significant difference in the number of positive identifications made between sober and intoxicated groups (Dysart et al., 2002; Hagsand et al., 2013; Yuille & Tollestrup, 1990). This null effect of intoxication can be interpreted from the perspective of Steele and Josephs' (1990) alcohol myopia theory, which posits an inverse relationship between the volume of alcohol consumed and the drinker's attentional capacity, with cognitive resources prioritised for the processing of the most central or salient information. According to this view, important visual objects such as human faces are assumed to be unaffected by modest doses of alcohol but peripheral information is increasingly neglected as residual attentional capacity diminishes.

The alcohol myopia account of visual attention receives a range of support. For example, in the perception literature Moskowitz and Sharma (1974) report the findings of a visual search task in which alcohol intoxication significantly impaired participants' ability to detect peripheral targets while engaged in a concurrent (centrally presented) counting task. In an eye tracking study examining alcohol's effect on scene perception, Moser, Heide and Kömpf (1998) later found intoxicated participants made longer fixations and more exploratory saccades when viewing regions of high semantic interest, thus reducing the time available to scan peripheral features. Hoyer, Semenec, and Buchler (2007) found higher doses of alcohol in a visual search task slowed detection speeds for low-salience targets located in spatially peripheral regions of the stimulus array, while speeds for the same targets positioned near the center of the array were unaffected by alcohol.

Evidence of alcohol myopia is also found in the memory literature. While alcohol in Yuille and Tollestrup's (1990) study had no effect on participants' ability to positively

identify a mock perpetrator's face from a lineup, it caused a significant drop in the amount of wider contextual information recalled from his staged crime. Furthermore, Schreiber Compo et al. (2011) compared the ability of a sober, alcohol intoxicated, and alcohol-placebo group to recall the details of a conversation they had engaged in with an experimental ''bartender'' several minutes prior. They found no difference in the amount of central information each group recalled (i.e., details of the bartender and what he said) but sober participants recalled more peripheral information than their intoxicated counterparts. This finding was recently supported by a study of eye movements in scene perception by Harvey, Kneller and Campbell (2013), who found that intoxicated participants focused their foveal attention on to a spatially and semantically central scene region significantly more narrowly than their sober counterparts. The alcohol group in this experiment also showed a concomitant decrease in the amount of accurate peripheral information they were able to recall from the visual scene.

If one assumes that an entire target face is spatially central or perceptually salient in a visual scene, alcohol myopia theory does not predict that mildly intoxicated viewers will struggle to positively identify the same face when presented at test. However, while this interpretation is consistent with the data on alcohol and face recognition, which shows no effect of intoxication on identification hit rates, Dysart et al. (2002) and Hilliar et al. (2010) report significant increases in the number of misidentifications (false alarms) made by intoxicated participants under target absent identification conditions.

The participants of Dysart et al. (2002) were required to identify an experiment recruiter from a single photographic image either of the recruiter herself or a female resembling her and significantly more intoxicated than sober participants incorrectly identified the lookalike as the target. In interpreting this finding Dysart et al. (2002) suggest that intoxication causes a narrowing of attention on to individual facial features rather than on to the face more generally. Specifically, they suggest that alcohol narrowed participants'

attentional focus on to their recruiter's salient hairstyle, which led to the rest of her face being less adequately encoded – a plausible suggestion given the distracting effect external face features such as hair have been shown to have on face memory generally (e.g., Frowd et al., 2012). Thus, when later presented with a show-up, those in the intoxicated target-absent group were more inclined to match their representation of the target's hair with that of the similar looking foil. This view of alcohol myopia therefore assumes a relative definition of feature salience determined by the level at which a viewer's attention is focused on a scene. For example, a perpetrator's face may be the most salient feature of a crime overall, attracting more attention than peripheral features, but when the attention of a witness zooms in on to the face itself, a prominent nose or unusual hairstyle may draw attention away from other less striking facial features, potentially encoding insufficient information in memory to discriminate it from similar looking faces later.

The attentional narrowing theory of face processing has also been used to explain the results of a recent examination of the effects of alcohol intoxication on cross-race face processing (Hilliar et al., 2010). As expected, Hilliar et al. (2010) observed the robust and well-documented own-race bias in face recognition (ORB) with placebo controls of both Asian and European origin. But they found intoxicated participants of both races falsely identified more own-race faces than sober counterparts, which significantly reduced the size of the ORB for the alcohol group. Converging with Dysart et al. (2002), Hilliar and colleagues suggest alcohol restricts attention during face encoding and add that this attentional deficit may impair the otherwise expert processing of same-race faces. The authors do not venture the specific mechanism disrupted by alcohol intoxication but one possibility is through its restrictive effects on visual scanning during face encoding.

Alcohol has been found to impair eye movements by slowing the velocity and extent of saccadic activity and by prolonging fixation times (Buser, Lachenmayr, Priemer, Langnau,

Gilg, 1996; Holdstock & de Wit, 1999; Moser, Heide & Kömpf, 1998; Nawrot, Nordenstrom & Olson, 2003; Wilkinson, 1976), so it may restrict visual attention during face processing via its adverse impact on gaze behaviour. Some researchers, though, favour a holistic view of face learning, which assumes the integrated configural information critical to expert perception is extracted at low spatial frequencies independently of gaze behaviour (e.g., Goffaux & Rossion, 2006; Heering, Rossion, Turati & Simion, 2008; Tanaka & Farah, 2003). However, Bombari, Mast and Lobmaier (2009) suggest that an increased focus on the centre of the face (i.e., the nose area) supports holistic processing by facilitating the extrafoveal capture of information from the whole face. But this view is inconsistent with the results of a study by Henderson, Williams and Falk (2005), who found that restricting fixations to a small target on the nose caused a 28% decrease in face recognition performance relative to a free gaze condition. In the unrestricted condition the typical encoding scan pattern was observed in which the overwhelming majority of fixations are directed to the eyes, followed by the nose and mouth (e.g., Althoff & Cohen, 1999; Groner, Walder & Groner, 1984; Stacey, Walker, & Underwood, 2005; Walker-Smith, Gale, & Findlay, 1977; Yarbus, 1967) but in which scanning between the eyes alone occupies around half of the encoding duration.

It is not clear why such emphasis is placed on the eyes but Henderson et al. (2005) suggest their scanning may support holistic processing through the extraction of relational information, such as the distance separating them, which may be computed directly from the length of saccades from one eye to the other. Others suggest this eye-centric scanning pattern is culturally-specific. In some Asian countries, for example, prolonged interpersonal eye contact is considered impolite, which perhaps explains why Asian viewers have been shown to gaze at the eyes less and the nose and mouth more than Western European counterparts (Blais, Jack, Scheepers, Fiset & Caldara, 2008). This pattern was not observed by Goldinger, He and Papesh (2009), though, who found both European and Asian groups attended more to

the eyes of own-race faces but to the nose and mouth of different-race faces. Goldinger and colleagues also found fixations to different-race faces were more lingering, less numerous, less extensive (as per the number of unique features visited), and more regressive (as per the number of features revisited) than those made to own-race faces perhaps reflecting a drop in the rate of information gathered from different-race faces.

Interestingly, this restricted gaze pattern closely resembles that shown by participants visually encoding under the influence of alcohol (e.g., Buser et al., 1996; Holdstock & de Wit, 1999; Moser, et al., 1998; Nawrot, et al., 2003; Wilkinson, 1976), hence, the present study considers whether reduced scanning also accounts for the inflated FA rates shown by the intoxicated participants of Dysart et al. and Hilliar et al. In order to examine this hypothesis, and to explore the role extensive fixations to the eyes plays in face processing, the eye movements of a group of white British participants were recorded as they encoded a series of own- and different-race faces under both alcohol and placebo treatment conditions. The number of fixations made to each stimulus face region and subsequent indices of face recognition accuracy were compared as a function of face race and alcohol treatment. Mean measures of saccadic distance, fixation duration and regressions were also compared between conditions.

When encoding own-race faces in the placebo condition, participants were predicted to show the classic inverted triangle-shaped scan path in which the majority of fixations are devoted to scanning the eyes, followed by the nose and mouth. In contrast, the sober encoding of different-race faces was expected to mirror the more restricted gaze pattern reported by Goldinger et al. in which scanning was less extensive and fixations more focused on the nose. Participants were also expected to show a restricted, centrally focused pattern of eye movements when intoxicated (cf. Harvey et al., 2013), during the scanning of both own- and different-race faces. For the recognition phase of the sober condition, the restricted viewing of

different-race faces was expected to lead to the classic own-race face recognition advantage. In the alcohol condition, however, where restricted encoding was expected for both face types, no significant own-race advantage was predicted (cf. Hilliar et al., 2010).

In addition to these specific hypotheses an exploratory analysis was conducted to examine the relationship between the encoding of specific facial features and subsequent face recognition performance. Of particular interest was the importance of fixations to the hair (Dysart et al., 2002; Frowd et al., 2012), forehead, eyes (Henderson et al., 2005), nose (Bombari et al., 2009) and mouth regions to face learning.

Method

Participants. A total of 32 British (Caucasian) undergraduate students were offered either course credit or £10 for participation in the study. The sample consisted of 21 females and 9 males ranging in age from 18–38 years (M = 23 years; SD = 6).

The experiment was advertised as an investigation of the impact of alcohol intoxication on cognition and social abilities. Prior to consenting, participants completed an alcohol advisory and screening questionnaire confirming their eligibility to take part and reminding them not to drive to the lab. The screen was designed to exclude all respondents under 18-years of age (legal age for drinking in the UK), contraindicated for alcohol consumption on medical grounds and those who had not consumed at least 6 units of alcohol in a single sitting during the previous 3 months. This measure and all other facets of the study were fully approved by the host university's ethics committee, and the experiment was administered with full adherence to the British Psychological Society Code of Ethics and Conduct.

Materials and Apparatus. Breath alcohol concentration (BrAC) in participants' deep lung air was recorded using a Lion Alcolmeter 500. The unit of alcohol measurement was

grams of alcohol per 210 litres of breath (g/210L).

For the encoding phase of the experiment participants were sequentially exposed to individual colour photographs showing the faces of 10 Indian and 10 European men in their twenties. The Indian faces were retrieved from the University of Massachusetts Computer Vision Lab's online face database (Jain & Mukherjee, 2002). The European faces were downloaded from the Psychological Image Collection at Stirling University and the Face Recognition Database from the Department of Computer Vision Science at the University of Essex. All faces were cropped from the neck up, and around the outer hairline. Each was displayed in the centre of a flat 17" eye tracking display monitor with a white background at a height of 20cm and, to maintain aspect ratio, a width that was free to vary. The size of each stimulus face was therefore comparable to those of real faces. Each wore a neutral expression with no adornments, headwear, eyewear or other distinguishing features visible. For the recognition task the same images were displayed along with 10 new Indian and European faces conforming to the same criteria. There were 40 Indian and 40 European faces in total, 20 of each for use in the alcohol treatment condition and the remainder in the placebo condition.

While viewing the stimulus images participants' eye movements were measured using a tower mounted SR Eyelink 1000 set for monocular recording. This high-speed, video-based unit uses pupil and corneal reflection (of infrared light) to sample eye movements at a rate of 1000Hz. The spatial resolution of these measures was 0.01º with a typical gaze position accuracy ranging from 0.25º to 0.5º. For the recognition task faces were displayed in the same dimensions via a desktop PC.

Design. The study conformed to a 2 (Race) × 2 (Alcohol Treatment) repeated-measures design. Each participant was tested across two consecutive days, receiving the alcohol treatment on one and the placebo on the other. The order in which these treatments

were administered was counterbalanced, with half the sample receiving the placebo treatment followed by the alcohol treatment, and vice versa. During the encoding phase of the experiment participants were shown a block of 10 Indian and a block of 10 European faces in the placebo condition. A different block of 10 Indian and 10 European faces was viewed in the alcohol condition. The stimulus sets were also counterbalanced such that half the participants encoded set A in the placebo condition and set B in the alcohol condition while the other half encoded set B in the placebo condition and set A in the alcohol condition.

Each recognition session was administered at least 6-hours later in order to allow those in the alcohol condition sufficient time to sober up for the memory test. This comprised of two blocks, one containing the 10 Indian faces viewed in the morning (hereafter referred to as *old* faces) mixed with 10 previously unseen (*new*) Indian faces, and the other, 10 old European faces mixed with 10 new European faces. In both the encoding and recognition phase the presentation order of the stimulus blocks was counterbalanced across participants and the faces within them presented to each participant in a different randomized order.

Procedure. Upon arrival for each testing session participants were breathalysed to confirm an initial BrAC of zero and weighed to determine how the size of their alcohol dose. They were then randomly assigned to one of the two treatment conditions. A single-blind procedure was administered. Those in the alcohol condition received a 500ml drink containing 1ml of ethyl alcohol per kg of body weight mixed with sugar free tonic water. Those in the placebo condition were served 500ml of tonic water with traces of ethanol dropped on to the surface of the drink and mist-sprayed over the entire glass. Participants consumed their drinks within 20 minutes then rested during a further 20-minute alcohol absorption period. They then rinsed their mouths with water to remove residual traces of alcohol and gave a second BrAC recording. After this breath test participants were also asked to report their subjective level of intoxication recorded on a 10-point scale (1 = "*completely*

sober"; 10 = "*as drunk as I have ever been*"). None were informed of their BrAC reading until the experiment was over.

Following the alcohol treatment participants were positioned at the eye tracker using a chin and forehead rest such that their eyes were 55cm from the 337mm (width) × 270mm (height) display monitor and, once comfortably seated, their fixations were calibrated using a 9-point procedure. This required the participant to remain fixated on the centre of a small black ring-shaped target that changed location to each of 9 positions on a 3×3 grid array in the centre of the screen. Successful calibrations produced fixation points that corresponded reasonably well with the configuration of the grid. Each measure was then validated by repeating the same procedure until the visual angle of deviation between the gaze positions predicted by the calibration model and those obtained from the validation samples were $< 0.5^{o}$ for each of the 9 grid positions.

After the calibration process participants were given these instructions: "*In this phase of the experiment you will be shown a series of people's faces. You do not need to do anything except sit and absorb the information presented to you*." Participants were then exposed to one block of 10 Indian faces and one block of 10 European faces. Each face was displayed for 3s and eye movements were sampled throughout this time. Display trials were separated by a 1s inter-stimulus interval and each block was separated by a short gaze drift correction procedure. After this face encoding phase participants were booked to return at least 6-hours later for the recognition task.

On their return participants were subjected to a further BrAC and subjective intoxication recording to ensure their sobriety prior to the recognition task. Before commencing this test they were given the following instructions: "*In this phase of the experiment we will show you some more faces and you will have to decide whether each face was shown to you in this morning's session (i.e., is an old face), or not (i.e., is a new face).*"

Participants then completed the two blocks of the face recognition task. The following day they received exactly the same treatment, only under the placebo condition if their initial visit involved alcohol or *vice versa*.

Race contact questionnaire. After the final recognition test on day-two participants completed a race contact questionnaire adapted from Hilliar et al. (2010). This was included to ensure that all had experienced significantly more contact with OR than DR faces prior to the experiment. The questionnaire invited participants to state their country of origin, country of residence, all previous countries of residence, and the duration of residence in each of these. They were also asked to state, on a 7-point scale, the degree to which they had interacted with white (European), mixed-race, Indian (Asian), black or other non-white race (1 = "*I rarely see them around my community*", 7 = "*They compose my entire circle of friends*").

Results

Intoxication levels. The amount of ethanol administered to participants in the alcohol condition ranged from 49ml to 108ml (M = 76ml; SD = 16) leading to a BrAC range of 0.03 to 0.10g/210L (M = 0.06g/210L; SD = 0.02). Note that the legal blood alcohol concentration for driving in the UK is 0.08% (≈0.08g/210L). BrAC measures for the placebo condition were all zero. Subjective intoxication ratings taken immediately before the recognition task ranged from 1 to 2 (out of 10) (M = 1.3; SD = 0.4) for the placebo condition, and 2 to 9 (M = 5.0, SD = 1.6) for the alcohol condition. A Wilcoxon Signed Ranks test confirmed that in the alcohol condition participants reported feeling significantly more intoxicated than in the placebo condition, $z = 5.11$, N = 34, $p < .001$. The mean breath alcohol measure for the alcohol condition taken just prior to the face recognition task (i.e., 6-hours after alcohol consumption) was 0.008 g/210L (SD = 0.004). The mean subjective intoxication level participants gave at

this stage of the experiment was 0. It should also be noted that the order in which participants received the alcohol and placebo treatments was not found to interact with any of the results reported below.

Different-race contact levels. Participants reported having had more contact with white (European) individuals on average (M = 6.53, SD = .57) than with Indian (Asian) (M = 3.84, SD = 1.94), black (African/Caribbean) (M = 4.13, SD = 1.83), mixed-race (M = 4.81, SD = 1.38) or other (non-white) (M = 2.47, SD = 1.61) individuals. Most importantly, a paired t-test confirmed the mean rating for European contact was significantly higher than for Indian contact, $t(31) = 7.24$, $p < .001$, $r = .79$, and no significant correlations were found between cross-race contact and own- and different-race face recognition performance (all ps > .05).

Fixation distributions. Each stimulus face was divided into 11 non-overlapping areas of interest corresponding to the hair, forehead, eyes, nose, mouth, chin, cheeks and ears, with data for the eyes, cheeks and ears collapsed across each respective pair. Figure 1 shows the mean proportion of fixations as a function of race, alcohol treatment, and face region with OR data shown in the upper panel and DR data in the lower panel. Note, these data so closely resemble the mean gaze duration data for each level of race, alcohol treatment and face region that the latter are not reported. As expected, participants allocated the majority of their fixations to the eyes (M = 55.67%, SD = 15.41) and nose (M = 15.70%, SD = 10.77) overall, with other face regions receiving little attention by comparison (M = 3.40%). A 2(Race) × 2(Alcohol Treatment) × 8(Face Region) repeated-measures ANOVA confirmed that this main effect of region was highly significant, $F(1.99, 61.74) = 296.86$, MSE = 517.78, $p < .001$, $\eta_p^2 = .91$ (Greenhouse-Geisser corrected for non-sphericity). Also as predicted, post-hoc Bonferroni comparisons confirmed that the mean percentage of fixations made to the eyes was significantly higher than those made to the nose ($p < .01$). Furthermore, fixation

frequencies to the eyes and nose were significantly higher than those made to all other face regions (all *p*s < .01).

(Figure 1 about here)

Figure 1 further reveals that the mean proportion of fixations participants allocated to the nose region was higher when intoxicated (OR faces = 18.71%, SD = 13.63; DR faces = 17.71%, SD = 13.12) than when sober (14.17%, SD = 9.56 and 12.23%, SD = 6.77 respectively); and higher to the eyes when sober (OR faces = 57.01%, SD = 13.99; DR faces = 59.64%, SD = 13.61) than when intoxicated (50.70%; SD = 16.86 and 55.33%, SD = 17.19 respectively). As hypothesised, the ANOVA confirmed that this Alcohol Treatment × Face Region interaction was highly significant, $F(1.52, 47.14) = 5.34$, MSE = 216.72, $p = .01$, $\eta_p^2 = .15$. Although the Alcohol Treatment × Face Region × Race interaction was not, $F(2.06, 63.85) = .55$, MSE = 60.56, $p = .59$, $\eta_p^2 = .02$ (Greenhouse-Geisser corrected for non-sphericity). The effects of Race, Alcohol Treatment, the Race × Alcohol Treatment interaction, and the Race × Face Region interaction were also non-significant (all *p*s > .1).

Saccadic distance. Table 1 shows four mean eye movement indices – saccadic distance, fixations counts, gaze durations and regressions – as a function of face type and alcohol treatment. Saccadic distance is a cumulative measure of scanning activity computed from the total length of all saccades made during the encoding period and measured in degrees of visual angle. Participants showed more extensive scanning activity with OR faces (M = 36.16°, SD = 17.99) than DR faces (M = 32.96°, SD = 17.76). They also scanned both face types more extensively when sober (M = 38.97°, SD = 20.94) than when intoxicated (M = 30.13°, SD = 14.81). As expected, a 2(Alcohol Treatment) × 2(Race) repeated-measures ANOVA revealed these effects of race, $F(1, 31) = 8.17$, MSE = 40.82, $p = .008$, $\eta_p^2 = .21$, and

alcohol treatment, $F(1, 31) = 7.34$, MSE = 340.43, $p = .01$, $\eta_p^2 = .19$, to be significant. The Alcohol Treatment × Race interaction, however, was not, $F(1, 31) = .001$, MSE = 23.83, $p = .973$, $\eta_p^2 = .000$.

(Table 1 about here)

Fixation counts. It is clear from Table 1 that participants made more fixations on OR faces (M = 9.33, SD = 2.21) than DR faces (M = 8.66, SD = 2.17) overall, and more fixations across all faces when sober (M = 9.67, SD = 2.45) than when intoxicated (M = 8.33, SD = 1.93). A 2(Race) × 2(Alcohol Treatment) repeated-measures ANOVA confirmed these predicted effects of race, $F(1, 31) = 16.05$, MSE = .90, $p < .001$, $\eta_p^2 = .34$, and alcohol treatment, $F(1, 31) = 26.71$, MSE = 2.13, $p < .001$, $\eta_p^2 = .46$, to be highly significant. Also as predicted, Table 1 shows the mean number of fixations participants made under the influence of alcohol varied little between face types, however, when sober they made significantly more fixations on own- than different-race faces, $F(1, 31) = 32.82$, MSE = .47, $p < .001$, $\eta_p^2 = .51$.

Gaze duration. Contrary to predictions, a 2(Race) × 2(Alcohol Treatment) repeated-measures ANOVA confirmed that the mean gaze duration in the sober condition (M = 382.95ms, SD = 308.25) was not significantly shorter than that of the alcohol condition (M = 416.29ms, SD = 275.85), and that mean gaze duration was not significantly shorter during the encoding of OR faces (M = 377.04ms, SD = 280.99) than DR faces (M = 422.20ms, SD = 303.11) (*p*s > .1). However, when contrasting treatment effects across race conditions it can be seen in Table 1 that alcohol caused only slightly shorter gaze durations for different- compared to own-race faces but, when participants were sober, their mean fixation durations were longer for different- than for own-race faces. The ANOVA confirmed that this interaction was significant, $F(1, 31) = 4.18$, MSE = 45935.94, $p = .049$, $\eta_p^2 = .12$.

Regressions. Participants made significantly more regressions when sober (M = 1.65, SD = .62) than when intoxicated (M = 1.33, SD = .52), $F(1, 31) = 28.64$, MSE = .11, $p < .001$, $\eta_p^2 = .48$. Furthermore, contrary to the results of Goldinger et al. (2009), they made significantly more regressions to regions of OR faces (M = 1.61, SD = .67) than DR faces (M = 1.37, SD = .47), $F(1, 31) = 9.45$, MSE = .21, $p = .004$, $\eta_p^2 = .23$. However, the Race × Alcohol Treatment interaction for the mean number of regressions was non-significant, $F(1, 31) = .036$, MSE = .174, $p = .852$, $\eta_p^2 = .001$.

(Table 2 about here)

Recognition accuracy (*d'*). The sensitivity with which participants were able to discriminate faces was measured using *d'*. Higher *d'* scores reflect an increasing ability to distinguish *old* from *new* faces whereas a score of 0 indicates no such ability (for further details see Stanislaw and Todorov, 1999). Mean *d'* scores for the OR and DR face conditions are displayed in Table 2 as a function of alcohol treatment. As expected, when sober participants showed superior recognition memory for OR faces compared to DR faces. However, in contrast to the findings of Hilliar et al. (2010), their performance remained unchanged when intoxicated. A 2(Alcohol Treatment) × 2(Race) repeated-measures ANOVA on the *d*' scores revealed a highly significant effect of race, $F(1, 31) = 37.90$, MSE = .42, $p<.001$, $\eta_p^2=.55$, but no significant effect of alcohol treatment, $F(1, 31) = .004$, MSE = .447, $p = .95$, $\eta_p^2 < .001$, and no significant Race × Alcohol Treatment interaction, $F(1, 31) = .001$, MSE = .287, $p = .98$, $\eta_p^2 < .001$.

Response biases. Further analyses on the recognition data were conducted to determine the extent to which the ORB was driven by more accurate recognition of OR faces (i.e., relatively more OR hits) or less accurate recognition of DR faces (i.e., relatively more

DR false alarms). Table 2 shows the mean hit (H) and false-alarm (FA) rate for each condition along with associated measures of response bias (*c*) and reaction time (ms). Note that negative values of *c* denote a tendency to respond *old* (a liberal response bias), positive values a tendency to respond *new* (a conservative response bias) with 0 signifying no response bias. Whether intoxicated or not, Table 2 reveals participants made a greater proportion of false alarms for DR faces (Placebo M = .45, SD = .22; Alcohol M = .43, SD = .19) relative to OR faces (Placebo M = .21, SD = .17; Alcohol M = .20, SD = .12). Whereas the number of hits for DR (Placebo and Alcohol M = .65, SD = .14) and OR faces (Placebo M = .63, SD = .21; Alcohol M = .63, SD = .16) was virtually equal. Analysis of the response bias measure (*c*) indicates that across alcohol conditions this pattern of results was caused by a liberal tendency to respond *old* to DR faces (M = -.125, SD = .38) and a conservative tendency to respond *new* to OR faces (M = .255, SD = .37). A 2(Alcohol Treatment) × 2(Race) repeated-measures ANOVA on the *c* scores confirmed that this main effect of race on response bias was highly significant, $F(1, 31) = 24.18$, MSE = .193, $p < .001$, $\eta_p^2 = .44$, and that the effect of alcohol treatment and the Race × Alcohol Treatment interaction were not (both *p*s > .1). Hence, the ORB in this experiment was large, driven by a high false alarm rate for DR faces and unaffected by alcohol intoxication.

(Table 3 about here)

Encoding fixations and recognition accuracy. To examine the importance of featural encoding to face memory, correlations between the percentage of fixations made to the hair, forehead, eyes, nose and mouth and *d'* scores were computed for each experimental condition (fixation percentages for the cheeks, ears and chin were too close to zero to warrant inclusion). These data are shown in Table 3 and have two notable aspects. The first is the

positive associations between encoding fixations to the hair and subsequent face recognition performance, a relationship that is consistent across conditions although significant only for own-race faces in the placebo condition and different-race faces in the alcohol condition.

The second is that an increase in encoding fixations to the eyes is associated with poorer memory for own-race faces irrespective of alcohol treatment. Although not tabulated, this negative association is significant only for the rate of recognition hits, not false alarms. Furthermore, the percentage of fixations to the eyes is negatively correlated with those made to all other face regions across conditions. These associations are large and significant for fixations to the hair, forehead, nose and mouth (ps < .05), indicating that an increased focus on the eyes came at the cost of fewer fixations to these particular regions.

In order to explore the extent to which the number of fixations made to these features predicts face recognition performance, a stepwise regression analysis was conducted for each experimental condition, with percentage of fixations to the hair, forehead, eyes, nose and mouth serving as predictors and *d'* scores the outcome variable. The results of these analyses are displayed in Table 4. In the placebo condition, the percentage of fixations made to the forehead emerged as the most significant positive predictor of different race face recognition performance, $F(1, 31) = 4.25$, $p = .048$. Fixations to the hair is the most predictive of own-race face memory performance in the placebo condition, $F(1, 31) = 14.17$, $p = .001$, and different-race face recognition in the alcohol condition, $F(1, 31) = 5.63$, $p = .024$, while *fewer* fixations to the eyes is the variable most predictive of own-race face recognition across both treatment conditions, $F(1, 31) = 9.89$, $p = .004$.

Discussion

This study examined the effects of alcohol intoxication on cross-race face recognition

and the role eye movements play in the service of face learning generally. The main hypothesis was that intoxication (i.e., alcohol myopia) and the non-expert processing of different-race faces independently restrict visual encoding, which was expected to lead to poorer recognition of all faces in the alcohol condition, and different-race faces in the placebo condition. This outcome was therefore expected to reduce or eliminate the own-race face recognition advantage (cf. Hilliar et al., 2010).

The prediction that different-race faces and alcohol intoxication would produce restricted scanning patterns was supported. Own-race faces were fixated more frequently, scanned more extensively and recognised more accurately than different-race faces – a result also observed by Goldinger et al. (2009), who suggest it reflects an increased rate of visual information gathering from own-race faces. However, this interpretation is tempered by the fact that the present participants made significantly more regressions to own- than different-race face regions, whereas Goldinger et al's (2009) volunteers showed the reverse pattern. It therefore remains unclear whether an increase in regressions reflects more extensive information gathering from own-race faces or more effortful encoding of different-race face features.

What is clear is that the ORB persists for a range of face stimuli scanned in a variety of ways across studies. For example, the distribution of fixations across face features in the current experiment was the same for both face types, whereas the ORB observed by Goldinger et al. (2009) was associated with proportionally more fixations to the eyes of own-race faces and the nose and mouth of different-race faces. The European participants of Blais et al. (2008), on the other hand, showed a bias toward fixating the eyes of all faces while their Asian participants made a preponderance of fixations to the more central nose region. Reconciling these mixed findings is difficult but they at least indicate that the ORB is not underpinned by a universal face scanning pattern at encoding, and that cultural and individual

differences exert a subtle influence on face encoding that is not fully understood.

The prediction that alcohol intoxication would restrict face scanning was supported although, contrary to expectation, this did not impair face recognition performance. More specifically, alcohol had a significant impact on the distribution of fixations across face features, contributing to a shift in foveal attention away from the eyes and toward the more central nose region of both face types. This is consistent with previous findings and provides further evidence of the attentional narrowing implied by alcohol myopia theory (Canto-Pereira, David, Machado-Pinheiro, & Ranvaud, 2007; Harvey et al., 2013; Hoyer, Semenec & Buchler, 2007; Moser et al., 1998; Moskowitz & Sharma, 1974). Also in line with earlier research is the impact alcohol had on encoding eye movements more generally, causing significantly fewer fixations and regressions, longer gaze durations and an overall reduction in saccadic activity (Buser, Lachenmayr, Priemer, Langnau, Gilg, 1996; Holdstock & de Wit, 1999; Moser, Heide & Kömpf, 1998; Nawrot, Nordenstrom & Olson, 2003; Wilkinson, 1976). Whether this reflects the general sedative properties of alcohol or a more specific action on the visual system is difficult to establish from these data, but Holdstock and de Wit (1999) report a dissociation between objective measures of visual impairment and subjective feelings of alcohol sedation, which suggests that the drug's effects on vision are selective. Encoding eye movements in the present study were also found to be influenced by the interaction of face type and alcohol treatment. As predicted, participants, when intoxicated, made a similarly small number of longer fixations across both face types, but, when sober, they made significantly more fixations of shorter duration to own-race faces, possibly reflecting more elaborate and expert own-race processing unfettered by alcohol intoxication.

As in the study by Hilliar et al. (2010), the own-race face recognition advantage observed here was large and driven by a high rate of false alarms for different-race faces, suggesting that less visual information is encoded from different- than own-race faces.

Nevertheless, contrary to prediction, the restricted pattern of visual scanning shown in the alcohol condition had was not associated with any impairments to face recognition performance. Therefore, the suggestion that alcohol impairs face memory through restricted visual encoding (Dysart et al., 2002; Hilliar et al., 2010) receives no support from these data. It is important to note though that participants in the present alcohol condition were sober when completing the retrieval element of the face recognition task, whereas those in the aforementioned studies were intoxicated throughout. The increase in misidentifications shown by the intoxicated groups of Dysart et al. (2002), and Hilliar et al. (2010), may therefore reflect an alcohol-based face retrieval deficit. This account is supported by a direct comparison of the average time current participants and those of Hilliar et al. took to decide if own-race faces were old or new. Hilliar et al's (2010) intoxicated group were 77.35ms slower than their sober counterparts deciding whether own-race faces were old or new, but in the present study participants were only 25.92ms slower making their decisions in the alcohol condition than in the sober condition. It is also supported by the absence of any other performance differences between the recognition data of these two experiments.

Given the disproportionately large number of fixations made to the eyes relative to other features during face learning, it is clear that an extensive foveal analysis of this region is of considerable importance to the task. Yet, curiously, the findings of this study show that too narrow a focus on the eyes during encoding is associated with poorer face memory. It is not clear why, but it may be due to the processing of potentially distracting emotional cues. In addition to their diagnostic value in discriminating faces the eyes offer the clearest window on to a person's emotional state (Itier & Batty, 2009). The present stimuli were designed to be emotionally neutral, but even the passive expressions of the eyes of these faces may have betrayed sufficient emotion to captivate the more empathic viewer. Those who focus less intently at this feature during encoding in order to pay more attention to other face features

may therefore avoid this potentially distracting effect to glean a more complete visual representation of the stimulus face. In particular, the present findings suggest that those inclined to extend their foveal analysis to the hair/forehead region are more likely to remember faces than those who focus more narrowly on the eyes.

Before concluding, the main limitations of this research should be addressed. Firstly, as only British Caucasian participants were tested it is important to determine whether the effects reported here generalise to other racial groups. Stimulus faces in future eye tracking work of this nature should be counterbalanced such that each appears in a different screen location across trials. This will help establish whether alcohol narrows visual attention on to a specific facial feature (e.g., the nose) or merely towards the geometric centre of the display field. In order to confirm that the present results genuinely reflect effects of face rather than image recognition, it is important that the 'old' faces presented during the recognition task of future studies be drawn from different images to those used to introduce the faces at encoding. Finally, the retrieval account of Hilliar et al's (2010) alcohol-ORB effect should be tested using a mixed experimental design in which cross-race recognition performance can be compared across conditions in which alcohol status during encoding and retrieval is matched and mismatched.

Conclusion

In accordance with alcohol myopia theory, intoxication led to a narrowing of foveal attention away from the eyes and toward the centre of the stimulus faces. It also both reduced the number and increased the length of fixations participants made on each face, thus decreasing the amount of scanning activity during face encoding overall. Also as predicted, differences in encoding eye movements were observed between own- and different-race faces, the latter being fixated less frequently and scanned less extensively suggesting a reduced rate

of visual information gathering that mirrors the effect of alcohol intoxication on the encoding of both types faces. However, contrary to expectation, reduced scanning caused by alcohol had no effect on participants' ability to remember faces. This should be contrasted with the reduced sober scanning of different-race faces, which is associated with a large drop in recognition performance and thus a significant own-race face recognition advantage. Taken together, these results indicate that previously reported alcohol-based impairments of face identification (Dysart et al., 2002; Hilliar et al., 2010) are not caused by restrictions to foveal attention during encoding.

An exploration of the relationship between the distribution of face fixations and subsequent recognition performance further reveals that viewers who focus the eye region too narrowly are show poorer face memory than those showing a more diffuse pattern of fixations. It is therefore suggested that processes of emotion recognition during encoding lead to an excessive focus on the eyes that may impair the ability of some viewers to remember faces.

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Table caption

Table 1. Mean eye movement indices as a function of face type and alcohol treatment. Saccadic distance is measured in degrees of visual angle. Standard deviations are shown in parentheses.

Table 2. Mean *d*', hit rates (H), false-alarm (FA) rates and response bias measures (*c*) as a function of face type and alcohol treatment. Standard deviations are shown in parentheses.

Table 3. Correlations between face recognition performance (*d*') and the proportion of fixations made to the hair, eyes and nose for each condition of face type and alcohol treatment.

Table 4. Stepwise regression analyses predicting face recognition performance (*d*') from encoding eye fixations, for each condition of face type and alcohol treatment.

Table 1

	Own race		Different race	
	Placebo	Alcohol	Placebo	Alcohol
Distance (°)	40.57 (19.69)	31.76 (15.46)	37.37 (15.52)	28.50 (14.58)
Fixation count	10.07 (2.24)	8.61 (2.16)	9.27 (2.70)	8.06 (1.68)
Gaze duration (ms)	322 (194)	432 (368)	444 (423)	400 (184)
Regressions	1.78 (0.69)	1.52 (0.66)	1.45 (0.55)	1.22 (0.39)

Table 2

	Own race		Different race	
	Placebo	Alcohol	Placebo	Alcohol
d'	1.28 (.75)	1.29 (.64)	.58 (.75)	.59 (.61)
H	.63 (.21)	.63 (.16)	.65 (.14)	.65 (.14)
FA	.21 (.17)	.20 (.12)	.45 (.22)	.43 (.19)
c	.25 (.44)	.26 (.29)	-.13 (.38)	-.12 (.38)

Table 3

Condition, Measure	Placebo *d′*	Alcohol *d′*
OR, Fixations to hair	.57**	.29
OR, Fixations to forehead	.31	.13
OR, Fixations to eyes	-.52**	-.50**
OR, Fixations to nose	.05	.26
OR, Fixations to mouth	.16	.16
DR, Fixations to hair	.13	.40*
DR, Fixations to forehead	.35*	.27
DR, Fixations to eyes	-.13	-.35
DR, Fixations to nose	-.24	-.02
DR, Fixations to mouth	.18	.15

Note. $n = 32$. *$p < 0.05$. **$p < 0.01$.

Table 4

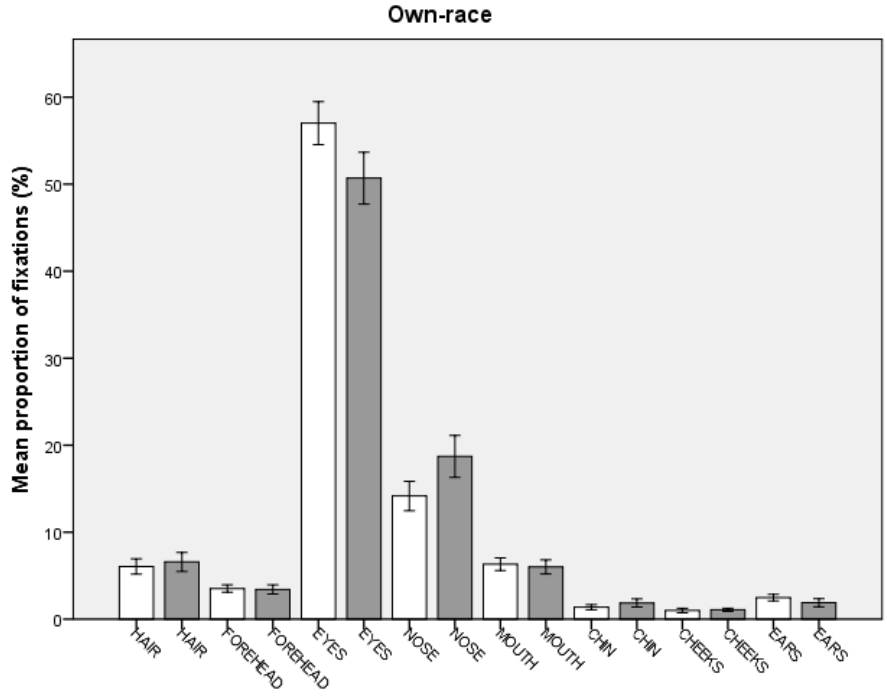
Condition, Predictor	*B*	*SE B*	β	R^2	ΔR^2
OR Placebo, Fixations to hair	.09	.02	.57	.32	.30**
OR Alcohol, Fixations to eyes	-.02	.01	-.50	.25	.22**
DR Placebo, Fixations to forehead	.08	.04	.35	.12	.10*
DR Alcohol, Fixations to hair	.04	.02	.40	.16	.13*

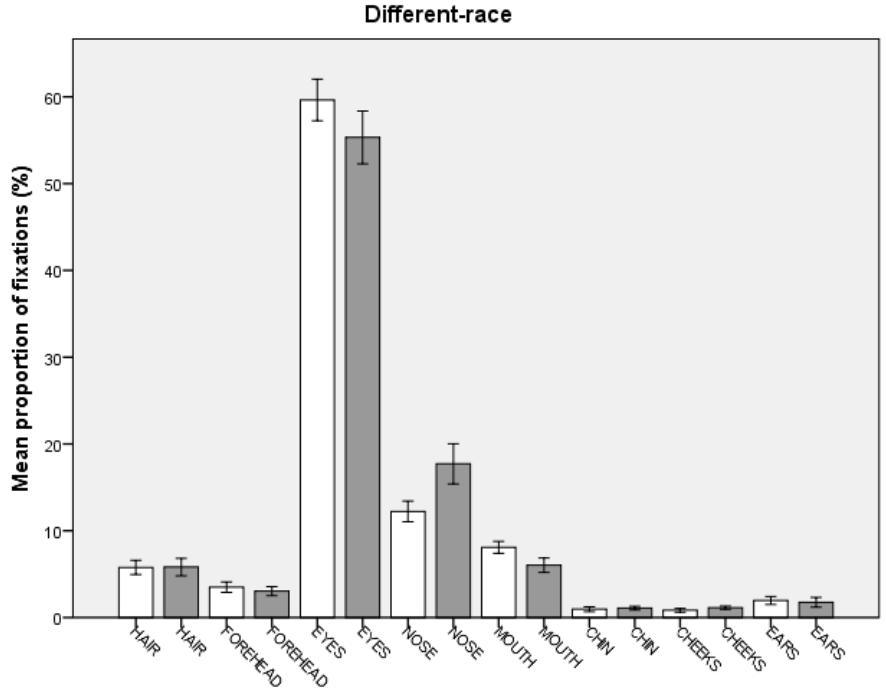
Note. $n = 32$. *$p < 0.05$. **$p < 0.01$.

Figure Captions

Figure 1. Mean proportion of fixations as a function of race, face region and alcohol treatment. White bars represent the placebo condition and grey bars the alcohol condition. Error bars show standard error of mean.

Figure 1


Own-race
Mean proportion of fixations (%)
0
10
20
30
40
50
60
HAIR
HAIR
FOREHEAD
FOREHEAD
EYES
EYES
NOSE
NOSE
MOUTH
MOUTH
CHIN
CHIN
CHEEKS
CHEEKS
EARS
EARS


Different-race
Mean proportion of fixations (%)
0
10
20
30
40
50
60
HAIR
HAIR
FOREHEAD
FOREHEAD
EYES
EYES
NOSE
NOSE
MOUTH
MOUTH
CHIN
CHIN
CHEEKS
CHEEKS
EARS
EARS