

Looking at others through implicitly or explicitly prejudiced eyes

**Bruce C. Hansen¹, Pamela J. Rakhshan^{1,2}, Arnold K. Ho³
and Sebastian Pannasch⁴**

¹Department of Psychology and Neuroscience Program, Colgate University, Hamilton, NY, USA

²Department of Psychology, University of Maryland, Baltimore, MD, USA

³Department of Psychology and Interdisciplinary Program in Organizational Studies, University of Michigan, Ann Arbor, MI, USA

⁴Department of Psychology, Engineering Psychology and Applied Cognitive Research, Technische Universität, Dresden, Germany

(Received 16 December 2014; accepted 12 June 2015)

It is well known that we utilize internalized representations (or schemas) to direct our eyes when exploring visual stimuli. Interestingly, our schemas for human faces are known to reflect systematic differences that are consistent with one's level of racial prejudice. However, whether one's level or type of racial prejudice can differentially regulate how we visually explore faces that are the target of prejudice is currently unknown. Here, White participants varying in their level of implicit or explicit prejudice viewed Black faces and White faces (with the latter serving as a control) while having their gaze behaviour recorded with an eye-tracker. The results show that, regardless of prejudice type (i.e., implicit or explicit), participants high in racial prejudice examine faces differently than those low in racial prejudice. Specifically, individuals high in explicit racial prejudice were more likely to fixate on the mouth region of Black faces when compared to individuals low in explicit prejudice, and exhibited less consistency in their scanning of faces irrespective of race. On the other hand, individuals high in implicit racial prejudice tended to focus on the region between the eyes, regardless of face race. It therefore seems that racial prejudice guides target-race specific patterns of

Please address all correspondence to Bruce C. Hansen, Department of Psychology, Neuroscience Program, Colgate University, Hamilton, NY 13346, USA. E-mail: bchansen@colgate.edu

We are very grateful to Landon D. Reid for his thoughtful guidance during the early phases of the current study. We would also like to thank Jens R. Helmert and Anja Strobel for their very helpful comments on earlier versions of the manuscript.

No potential conflict of interest was reported by the authors.

This research was supported by a Colgate Research Council grant to BCH and by the FP7-PEOPLE-2009-IEF program [grant number 254638] to SP.

looking behaviour, and may also contribute to general patterns of looking behaviour when visually exploring human faces.

Keywords: Eye movements; Implicit prejudice; Explicit prejudice; Human faces; Racial bias.

Active vision is characterized by the sampling of visual information through eye movements. During fixations—brief periods of time where the eyes remain relatively stable—information from the fixated region is processed. High visual acuity is limited to the small foveal region of the visual field. Therefore, to acquire high quality visual input from different regions, the eyes are rapidly moved from one region to another by saccadic eye movements. In active vision, it has been repeatedly shown that visual attention is usually directed to the location of fixation (e.g., Findlay & Gilchrist, 2003; Henderson, 2007). In contrast, during passive vision (which is achieved mostly under laboratory conditions), visual attention can be shifted without moving the eyes (e.g., Posner, 1980).

The deployment of fixations during extended viewing involves a calculated exploration of stimulus features largely guided by automatic processes, as well as controlled (or “voluntary”) processes that involve the viewer’s expectancies of where to find useful information (e.g., Borji & Itti, 2014; Henderson, 2007). Relevant to the current study, it is well known that during free-viewing of faces (i.e., viewing that is largely exploratory in nature), humans (specifically, Westerners) deploy fixation sequences that generally follow a T-like pattern between the eyes, nose, and mouth, with a tendency to fixate more on the eyes (e.g., Blais, Jack, Scheepers, Fiset, & Caldara, 2008; Henderson, Williams, & Falk, 2005; Janik, Wellens, Goldberg, & Dell’Osso, 1978; Walker-Smith, Gale, & Findlay, 1977). However, it is still unknown whether internal biases of the observer, such as racial prejudice in particular, can lead to differential fixation patterns or scanning sequences (collectively referred to as “looking behaviour”) during the free-viewing of faces that are the target of prejudice. The current study is therefore aimed at exploring whether or not different levels of racial prejudice (either implicit or explicit) can play a role in shaping how White observers look at Black faces.

We begin with a brief background review of the theoretical and empirical motivations that lead us to ask the question stated above, followed by a more detailed development of the primary and secondary questions addressed in the current study.

Looking behaviour is guided by schemas

It is largely accepted that during the active scanning of a wide variety of visual stimuli, we use internalized referents, commonly referred to as schemas (i.e., generalized semantic and spatial knowledge built up through previous experience), to

guide our looking behaviour (Callan, Ferguson, & Bindemann, 2013; Hayhoe & Ballard, 2005; Tatler, Hayhoe, Land, & Ballard, 2011; for a detailed review see Land, 2009). Specifically, the majority of what we fixate during free-viewing of a given environment (or when viewing is guided by a specific task, such as during encoding for later recognition or action planning) can be directed by our expectations and memories of where to find useful information (Hannula et al., 2010; Malcolm & Henderson, 2010; Vö, Zwickel, & Schneider, 2010). Such a strategy has been likened to perception as a schema-guided “hypothesis” about what is being perceived, with our subsequent fixations acting to gather information in order to “test” that hypothesis (Friston, Adams, Perrinet, & Breakspear, 2012; Gregory, 1980). As noted earlier, when free-viewing faces, Western observers tend to follow a schematized viewing strategy that produces a T-like pattern (e.g., eyes, nose, and mouth), whereas Easterners tend to fixate more on the nose (e.g., Blais, et al., 2008; Caldara, Zhou, & Miellet, 2010). Further, when Whites free-view White and Black faces simultaneously (i.e., intergroup context stimulus paradigm), a similar schematized pattern is observed, but with more of an emphasis placed on the eyes of White faces stimuli (Kawakami et al., 2014, Experiment 1).

Influence of stereotyping and prejudice on schema driven looking behaviour

Previous research has shown that racial prejudice can modulate schematized (or stereotypic¹) representations of faces that are the target of prejudice (e.g., Dotsch, Wigboldus, Langner, & van Knippenberg 2008; Horry & Wright, 2009; Hugenberg & Bodenhausen, 2003, 2004). For example, Dotsch and colleagues (2008) used a classification image analysis paradigm where participants viewed two copies of a constant averaged face (i.e., a “base face”) that either had visual noise added or subtracted from it, and were asked to choose the face that looked “more Moroccan” on a trial-by-trial basis. The average of all base-face-in-noise-images selected on each trial as “more Moroccan” was taken to produce a stereotypical classification image (see Dotsch et al., 2008 for further details). Classification images produced by high-prejudice participants were independently rated as highly criminal looking and low in perceived trustworthiness, with the opposite true for classification images yielded by low-prejudice participants. While it has been demonstrated that racial prejudice can influence facial stereotypes (as noted above), it is currently unknown whether such influences can modify how viewers look at faces that are the target of prejudice. Work exists showing that differential forms of racial prejudice can influence eye movements at a very coarse level, specifically in the form of the shifting of overt attention between faces that are and are not the target of racial prejudice. For instance, when engaged in a mock interview paradigm, participants low in implicit

¹Note that schemas and stereotypes can be used synonymously in the current study.

prejudice tend to spend more time making visual contact with Black participants (compared to White participants), while those high in implicit prejudice show no difference in visual contact with either race (Dovidio, Kawakami, Johnson, Johnson, & Howard, 1997). Further, though less directly related, individuals who are highly extrinsically motivated to respond without prejudice tend to engage in early (possibly automated) attentional deployment to Black face stimuli as assessed through eye-tracking or in dot-probe paradigms (Bean et al., 2012; Richeson & Trawalter, 2008; Trawalter, Todd, Baird, & Richeson, 2008). Still, such influences speak more directly to global shifts of overt attention via eye movements, and do not speak to whether specific exploratory fixation patterns can be influenced by racial prejudice when viewing different race faces.

The current study

Taken together, previous research suggests that our looking behaviours in general are guided by schematic representations, and that face perception in particular can be influenced by stereotyping and prejudice. However, there currently exists a surprising gap in our knowledge concerning whether prejudiced individuals will look at Black faces differently than at White faces. The current study was therefore aimed at filling the gap.

Concerning the role of schema guided looking behaviour, there exists a wealth of eye-tracking literature reporting that such representations can act on the direction of eye movements through a dynamic interplay of both automatic and controlled (i.e., voluntary) processes (e.g., Callan et al., 2013; Hayhoe & Ballard, 2005; Henderson & Pierce, 2008; Kayser, Nielsen, & Logothetis, 2006; Tatler et al., 2011; Land, 2009), with more automatic processes active early in visual exploration (Tatler, Gilchrist, & Rusted, 2003), and being driven more by stimulus features. Specifically, Pannasch, Helmert, Roth, Herbold, and Walter (2008) report evidence that suggests the first two seconds of visual inspection largely involves automatic processes, whereas the later interval of 4–6 s involves viewing behaviour that is predominantly controlled by voluntary processes. In terms of face perception, a similar automated vs. voluntary trade-off has been observed whereby participants extrinsically motivated to control prejudice engage in early coarse overt attention deployment (assessed via eye-tracking) to Black face stimuli, with a later deployment to White face stimuli (Bean et al., 2012). Thus, should racial stereotypes play a role in informing the automated and voluntary control processes that direct eye movements, one might expect to find differential fixation strategies associated with each, possibly dissociated as a function of viewing time. Exactly how those automated and voluntary strategies are expressed may be related to the different forms by which racial prejudice is held and exhibited by the observer. Specifically, we know from decades of research in social cognition that implicit and explicit (or automatic and controlled, respectively) components of prejudice can lead to different

downstream consequences (e.g., [Devine, 1989](#); [Dovidio & Gaertner, 1998](#); [Dovidio, et al., 1997](#); [Greenwald & Banaji, 1995](#); [Greenwald, McGhee, & Schwartz, 1998](#)). Additionally, neuroimaging research has shown separable brain signals associated with automated expressions of prejudice compared to more voluntary and controlled expressions of prejudice (e.g., [Cunningham et al., 2004](#); [Ito & Bartholow, 2009](#); [Phelps et al., 2000](#)), suggesting the involvement of different neural networks underlying implicit and explicit prejudice. Given that eye-movement behaviour can be differentially directed by automatic and controlled processes, it is possible that differences in looking behaviour over viewing time may be observed between individuals high in implicit prejudice compared to those high in explicit prejudice. Thus, as a secondary aim of the current study, we sought to explore whether implicit and explicit prejudiced looking behaviour is separable as a function of viewing time.

In sum, the current study addresses the above questions by recording the eye movements of White participants varying in their level of implicit or explicit prejudice while free-viewing different race faces. Our specific questions involve examining exploratory looking behaviour along its three primary dimensions, namely fixation location patterns and scanning sequences, and are as follows:

- (1) Do overall patterned fixation differences between participants (i.e., exploratory fixation on specific parts of Black faces among Whites) vary as a function of the observer's level and type of racial prejudice?
- (2) Are the fixation differences associated with high implicit or explicit prejudice separable over viewing time?
- (3) Whereas the first two overarching questions explore the locations where Whites fixate on Black target faces, the third overarching question concerns the consistency of how Whites scan Black faces as a function of racial prejudice. That is, do differently prejudiced Whites scan different exemplars of Black faces in a sequentially consistent fashion?

We chose a free-viewing paradigm since it is likely to produce automated as well as voluntary viewing strategies (e.g., [Fischer, Graupner, Velichkovsky, & Pannasch, 2013](#); but see [Tatler et al., 2011](#) for critical remarks). For simplicity, we focused the current investigation on racial prejudice of Whites against Blacks. Our primary stimulus set therefore consisted of images of a range of Black faces. We also included White faces as a control, and Asian faces to help protect the study's cover story, which was described as a general face perception experiment. For our analysis, we examined fixation behaviours at two different levels. The first level of analysis pertained to patterned fixation biases. Specifically, we examined whether differently prejudiced individuals vary in their fixation patterns (i.e., whether certain facial regions were fixated longer and/or more frequently than others). The second level of analysis pertained to the global fixation strategies. That is, we examined whether differently prejudiced

individuals would show divergent scanning behaviour (i.e., the sequence of fixations from one facial region to the next) dependent on level and type of racial prejudice.

METHOD

Apparatus

All stimuli were presented on a 21 inch Viewsonic (G225fB) monitor driven by a dual core Intel[®] processor (1.33GHz \times 2). Maximum luminance output of the display monitor was 100 cd/m², the frame rate was set to 85 Hz, and the resolution was set to 1024 \times 768 pixels. The monitor was viewed at a distance of 91.5 cm. Head position was maintained with an SR Research chin and forehead rest.

Gaze fixations were sampled monocularly at 1 kHz using an SR Research Ltd EyeLink 1000 infrared remote eye-tracking system with on-line detection of saccades and fixations. The EyeLink desktop mount (camera and illuminator) system was driven by a dual core Intel[®] processor (1.33GHz \times 2). The desktop mount was situated in front of the stimulus display monitor (out of direct view) 52 cm from the participants. Fixation location measurement accuracy was better than 0.5° of visual angle. Saccades were identified by deflections in eye position in excess of 0.1°, with a minimum velocity of 30°/s and a minimum acceleration of 8000°/s², maintained for at least 4 ms.

Participants

Sixty-nine White volunteers (40 female, $M_{\text{age}} = 18.7$, all naïve to the purpose of the study and its measurements) from Colgate University participated in the experiment. All had normal (or corrected to normal) vision and were compensated for their participation. The current study conformed to the ethical standards of the Federal Code of Regulations Title 45 (Public Welfare) and Department of Health and Humans Services, Part 46 (Protection of Human Subjects). All experimental and consent procedures were reviewed and approved by Colgate University's Institutional Review Board. Institutional Review Board-approved informed written consent was obtained from each participant.

Experiment materials

Twenty-four colour images of whole human faces exhibiting a neutral expression were gathered from the Colgate Face Database (details about the database can be found at <http://psych.colgate.edu/~bchansen/VPL/BCH%20Lab%20CFDB.html>). Faces were selected from three different racial groups (eight faces per group: Asian, Black, and White, four female and four male for each group). The inclusion of White and Asian faces enabled us to explore whether any

observed fixation biases for the Black face stimulus set were specific to differences in racial prejudice, and specific to that stimulus set. All face stimuli subtended $\sim 14.3^\circ \times 10^\circ$ of visual angle, and all within race stimuli were aligned in space according to the primary facial features (i.e., eyes, nose, and mouth). Lastly, the face stimuli were looking forward in the direction of the participant.

Implicit prejudice was assessed using the Implicit Association Test (IAT) following the original procedure described by [Greenwald et al. \(1998\)](#), and explicit prejudice was assessed with the Quick Discrimination Index (QDI; [Ponterotto et al., 1995](#); [Utsey & Ponterotto, 1999](#)). The IAT version used here was the standard seven-block Black-White/Good-Bad IAT, and consisted of a computer run assessment of the strength of automatic associations and followed exactly the testing protocol utilized by the Harvard Project Implicit website (see [Greenwald, Nosek, & Banaji, 2003](#) for details regarding the scoring algorithm). The QDI is a self-report measure that assesses attitudes toward racial equality and gender equity; it is composed of three subscales: general attitudes towards racial diversity; affective and personal attitudes as they pertain to racial contact; and attitudes regarding women's equity ([Ponterotto, et al., 1995](#); [Utsey & Ponterotto, 1999](#)). While the QDI consists of 30 items, each utilizing a 5-point rating self-report scale, only items pertaining to cognitive and affective attitudes towards racial diversity were analyzed (16 items in total). All 16 QDI items were coded such that more prejudiced responses contributed to larger overall scores.² It is important to note that the QDI measures attitudes toward racial diversity in general and thus not specifically attitudes towards African Americans. We chose to use this measure as it allows for a safeguard against respondents' feeling that they were being specifically queried about Black-White prejudice and possibly tempering their responses as a result: race relations between Blacks and Whites is an especially sensitive topic at the university where this study took place). Nevertheless, as detailed in Note 2, the primary difference between the QDI and IAT in the current study concerned *explicit versus implicit measurement* of anti-Black bias, and not some other substantive difference such as anti-Black bias versus attitudes toward diversity in general.

²To assess whether the QDI is related to an explicit measure more directly analogous to the IAT in terms of face validity, we also collected data from a separate sample of participants recruited through Amazon MTurk ($n = 100$). Three explicit items were used to assess relative preference for Whites over Blacks (i.e., analogous to the IAT): (1) "Which statement best describes you?" (1 = "I strongly prefer Blacks to Whites" to 7 = "I strongly prefer Whites to Blacks"), (2) "Please rate how warm or cold your feelings are toward the following: Blacks" (1 = "Very cold" to 7 = "Very warm"), and (3) "Please rate how warm or cold your feelings are toward the following: Whites" (1 = "Very cold" to 7 = "Very warm"). The response to the second item was subtracted from the third to create a difference indexing relative preference of Whites over Blacks. The QDI score was computed as described above ($\alpha = .89$, $m = 2.45$, $SD = .68$). We found that the QDI was strongly related to item 1 above ($r = .48$, $p < .001$) and to the item 3 minus item 2 differential ($r = .43$, $p < .001$). Thus, we can be assured that the primary difference between the QDI and IAT in our study concerned explicit versus implicit measurement and not some other substantive difference.

Experimental procedure and analysis

All participants completed the QDI as part of a mass pre-screening session which contained several other questionnaires not associated with the current experiment. Experimental sessions for each participant began with a 9-point calibration of the eye-tracking system. Following the successful calibration, participants viewed all 24 faces in random order; each single face image was shown for 7 s while participant eye movements were recorded. Between each image, participants had to fixate a single fixation dot in order to perform a drift check that ensures accuracy of calibration. Prior to the experimental sessions, all participants were told that the study investigated how humans encode faces using viewing strategies. They were told that *both* the 9-point calibration and face viewing session were necessary to calibrate the eye-tracker. Participants were asked to simply look at each face as they would if examining a photograph of a person's face (i.e., free-viewing, though not completely without task). Once the eye-tracking session was complete, participants were moved to a different computer where they completed the IAT. The IAT was described as a further calibration procedure to assess typical categorization response speeds on a participant-by-participant basis. That is, participants were lead to believe that all "calibration" procedures (the 9-point calibration, face viewing session, and the IAT) were necessary in order to correctly measure their behaviour in a subsequent face perception study (which, unknown to the participants, would never take place).

Once each participant completed the IAT, (s)he was debriefed as to the actual purpose of the study (i.e., including the fact that the face viewing session, IAT, and previously completed QDI were the actual experiment). All participants were queried about the purpose of the study (including the "calibration" procedures) and none reported being aware of its goal or that the "calibration" procedures were the actual experiment.

Raw eye movement data were preprocessed by removing the first fixation of each trial as it would likely be substantially prolonged due to the image onset (e.g., Pannasch, Schulz, & Velichkovsky, 2011), fixations with durations of less than 40 ms, fixations around eye-blinks, and fixations outside the presentation screen. This preprocessing ensures that only valid eye movements are considered for further testing (e.g., Holmqvist et al., 2011). Following the preprocessing, fixation data from each participant were separated into "low prejudice" or "high prejudice" groups based on each participant's score from the IAT or QDI. For example, for a given participant's data to qualify as being a part of the "low" implicit prejudice group, that person's IAT score had to fall within the lowest 33.3% of all observed IAT scores. Alternatively, for a given participant's data to qualify as being a part of the "high" implicit prejudice group, that person's IAT score had to fall within the highest 33.3% of all observed IAT scores. The same data sorting procedure was used to split data into explicit "low" and "high" prejudice groups based on the QDI.

Subsequently, gaze fixation location data for each prejudice group were analyzed using in-house MATLAB (R2011b) code developed from the iMap algorithm (Caldara & Mielle, 2011; Mielle, Lao, & Caldara, 2014). The application of the iMap algorithm follows a two-step process: across-participant-averaged duration-weighted fixation heat maps are created, followed by the generation of statistically significant duration-weighted difference maps (i.e., statistically validated maps of fixation differences).³ What follows is a brief account of the operations involved in each step (see Caldara & Mielle, 2011 for further details). To create a given duration-weighted heat map for each participant, all fixations were mapped across the entire 7 s viewing period to a single matrix and normalized by the maximum fixation duration in milliseconds. Thus, the initial heat maps consist of pixel locations containing the weighted duration of each fixation and were then smoothed using a Gaussian kernel with a standard deviation of .5° of visual angle to account for the error due to the eye-tracker accuracy. Next, within the respective group (low or high prejudice, IAT or QDI), all participant duration-weighted fixation maps were summed together and normalized (i.e., converted to Z-scores) for each stimulus race set, resulting in group duration-weighted fixation heat maps for White and Black faces (see Figure 1). Therefore, all faces within our stimulus set were aligned in image space with respect to the eyes, nose, and mouth in order to generate composite heat maps across all faces within a set for each participant. It's worth noting that, due to the face stimuli available to us, the crucial features were not aligned across face race image sets, and so cross-race statistical significance testing could not be performed (see Caldara & Mielle, 2011 for further details). In order to minimize any influences caused by sporadic fixations, random fixation heat maps were generated for each participant (constrained to the face region). Specifically, for each participant and face stimulus, a fixed number of randomly

³One alternative to this sorting method (which amounts to dropping participant data in the middle one-third of either the IAT or QDI) is to weight the heat maps (see text for further details) according to participant prejudice level (i.e., "low" or "high") within each type (i.e., implicit or explicit) using the scores measured by the IAT or QDI. Thus, different duration weighted heat maps could be created for each face race set for each prejudice measure using *all* participant data (as opposed to the top and bottom one-third only). Using the IAT as an example, a set of "high" implicit prejudice heat maps could be created whereby all participants' heat maps (Black face set and White face set) were weighted by their corresponding IAT score. Therefore, participants with higher (i.e., more prejudiced) IAT scores would contribute more to an averaged heat map compared to those participants with lower IAT scores. For the "low" implicit prejudice heat maps, all participants' heat maps could be weighted by 1.0 minus their IAT score. Thus, participants with lower (i.e., less prejudiced) IAT scores would contribute more to an averaged heat map compared to those participants with higher IAT scores. The same procedure could be carried out for the explicit measure of prejudice (QDI), with the exception that all QDI scores would be normalized to the maximum possible score (i.e., 80) for the 16 QDI items utilized in the current study. We ran this analysis and observed results that were virtually identical to those with the bottom and top one-third split method described in the text. Since the weighting method could not be applied to all analyses reported in the current study, we chose to only report results from the bottom and top one-third splits for the sake of simplicity.

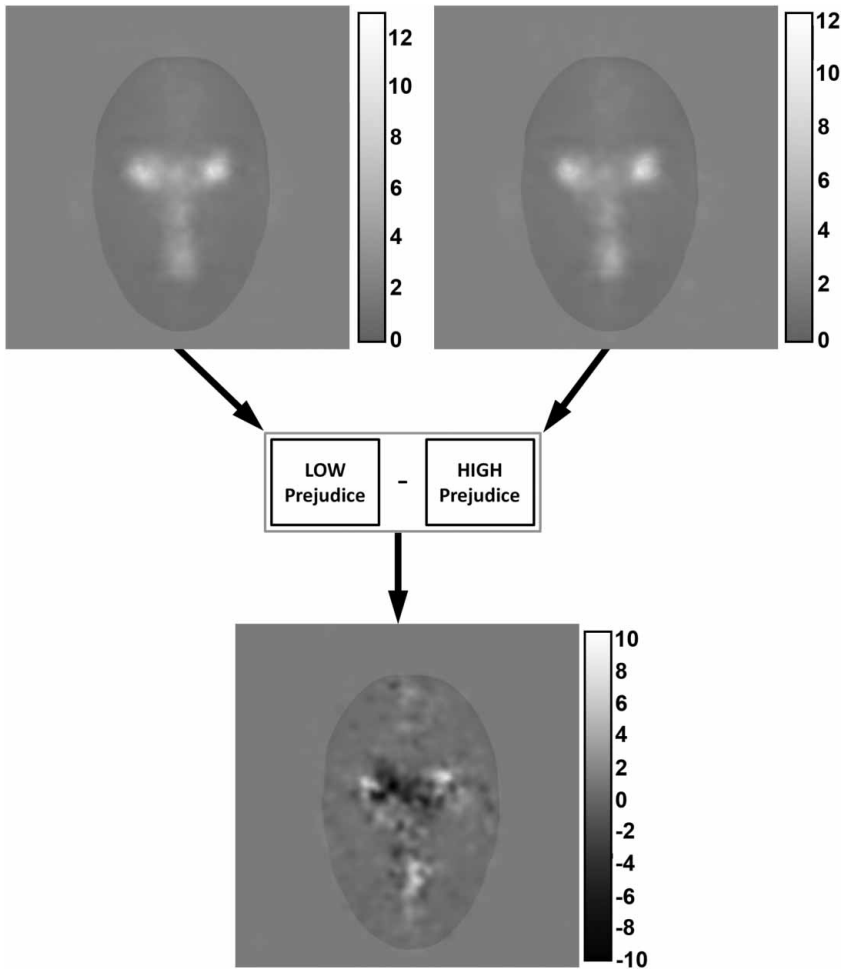


Figure 1. Illustration of the iMap algorithm for generating statistically-validated patterned fixation bias maps for participants classified as high or low in implicit racial prejudice (note that the explicit bias maps were generated in an identical manner). The example given here is for the Black face stimulus condition. Along the top row are the weighted fixation “heat maps”, with “low” prejudiced participants’ heat map on the left, and “high” prejudiced participants’ heat map on the right (the brighter the heat map region, the stronger the bias for fixating that region). The heat maps have been superimposed on a reference face that was generated using FantaMorph (version 4) to morph all faces within the Black face condition (i.e., a morphed “average”). Note that while the morphed faces shown above have the hair and ears removed, participants actually viewed individual faces with those features included. Once Z-scored heat maps were generated for each level of prejudice, the Z-scored high prejudice heat map was subtracted (pixel-by-pixel) from the Z-scored low prejudice heat map, with the resulting difference map Z-scored (brighter regions indicate low prejudice fixation biases, with darker regions indicating high prejudice fixation biases). A statistical threshold (here $Z_{crit} = |4.25|$; $p < .001$) is set, and only pixel Z-scores beyond the criterion are preserved (not shown here, refer to text for further detail).

positioned fixations were generated (using the number of fixations that participant produced when viewing that face). In order to assign random fixation durations to each randomly positioned fixation, we randomly sampled (without replacement) a fixation duration from that participant's fixation data for that face and randomly assigned it to one of the randomly placed fixations. The random duration-weighted heat maps were then subtracted from each of participant's duration-weighted heat maps described above. This additional step ensures that fixations that can be explained by chance are excluded from the iMap analysis. Finally, duration-weighted fixation heat maps for high prejudice were subtracted from low prejudice—either for IAT or QDI—to create fixation statistical difference maps, with the differences converted to Z-scores ($Z_{\text{crit}} = |4.25|$; $p < .001$). Clusters of statistically significant fixation differences were determined using a cluster analysis that grouped fixation differences (i.e., bias due to prejudice level) beyond Z_{crit} (for further details see Chauvin, Worsley, Schyns, Arguin, & Gosselin, 2005).

The second level of analyses was focused on whether different levels (low vs. high) and types (implicit vs. explicit) of racial prejudice would lead to divergent scanning behaviour (i.e., the sequence of fixations from one facial region to the next). Therefore, we employed the ScanMatch algorithm (Cristino, Mathot, Theeuwes, & Gilchrist, 2010) which evaluates the spatial and temporal similarity of fixation sequences. This analysis tells us whether participants with a certain level of prejudice engage in more or less similar scanning strategies when exploring Black or White faces.

The preprocessing and grouping of eye movement data was the same as described in the iMap analysis. Using the ScanMatch algorithm in MATLAB, letter sequences were created, retaining fixation location, time and order information for each individual face inspection. Pairs of these sequences are then compared using the Needleman-Wunsch algorithm (Needleman & Wunsch, 1970) to find the optimal alignment between a pair. The correspondence between two sequences is expressed by a normalized similarity score (normalized between 0 [no correspondence] and 1 [identical]). In order to calculate the similarity scores, we initially created region of interest (ROI) maps for the four different face templates (i.e., IAT Black, IAT White, QDI Black, and QDI White). The ROIs were derived from the four normalized fixation bias maps shown in Figure 3 (see Results for details regarding Figure 3). ROIs were defined in a data-driven manner by tracing the contours between the different biased fixation regions. Thus, a given ROI would consist of a location on a given face template that was fixated longer and more frequently by either low or high prejudiced individuals. Each ROI within a given map was coded with a unique number, with the background (i.e., the area surrounding the face) coded with a single unique number. The rationale here is that we were not concerned with coding where on the background participants fixated, just that they had fixated a non-face region. For the temporal binning we used 50 ms as it has been demonstrated to give the most accurate sampling across a wide variety of fixation durations (see Cristino et al., 2010, p. 693). To clarify, within a given fixation sequence, a fixation with a duration of 85 ms would

be counted only once while a fixation of 200 ms would be counted four times. Furthermore, we used a gap penalty of “0” because it has been shown to facilitate an optimal global alignment of fixation sequences (see [Cristino et al., 2010](#), p. 695).

Using ScanMatch, we ran pairwise comparisons to examine whether participants viewed one Black face in the same way they viewed another Black face. We also did this with the White target faces. Finally, as we did with the iMAP analyses, we split participants up by their prejudice levels, to examine whether high or low prejudice participants were more consistent in the way they viewed target faces within the same race.

RESULTS

Participant IAT and QDI scores are plotted against one another in [Figure 2](#). We were unable to obtain QDI data from one participant. That participant’s eye-tracking data were therefore not included in any of the analyses described below. The mean and median IAT score (i.e., D) was 0.55 and 0.56, respectively (lowest one-third IAT score $D = 0.25$, $SD = 0.15$, $n = 22$; highest one-third IAT score $D = 0.82$,

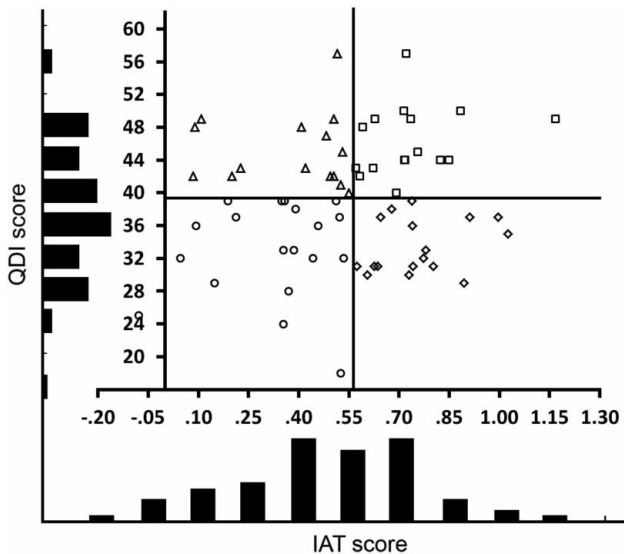


Figure 2. Within-subject IAT and QDI scores (with IAT on the x -axis and QDI on the y -axis). Axes histograms show the distribution of scores for each prejudice measure (both are well fit by a Gaussian curve with skewness and kurtosis parameters close to zero). The scatter plot has been split (solid black lines) at the median score for the IAT and QDI. Scores that fall within each of the four quadrants are plotted with different symbols (lower left: open circles; upper left: open triangles; upper right: open squares; lower right: open diamonds). The median splits shown correspond to the boundaries used in the prejudice sub-type analysis described later.

$SD = 0.12$, $n = 22$). The mean and median QDI score for the 16 racial items was 39.07 and 39, with a Cronbach's alpha of 0.835 (lowest one-third QDI score $M = 30.3$, $SD = 3.8$; highest one-third QDI score $M = 47.6$, $SD = 3.9$). The correlation between the IAT and QDI was .13 ($p = .27$). It is not uncommon for implicit and explicit measures of socially sensitive topics such as prejudice to be weakly or not at all correlated (Nosek, 2005).

Fixation patterns as a function of racial prejudice

To explore our first question concerning the region of Black target faces that Whites fixate on as a function of racial prejudice, we used the patterned fixation biases analysis (iMap Analysis) described above. Figure 3 shows the statistically significant fixation bias pattern maps (i.e., difference maps illustrated in Figure 1) between low racial prejudice (LRP) and high racial prejudice (HRP) eye-tracking data (top panel: IAT; bottom panel: QDI) for the Black face stimulus set, as well as the White face stimulus set. The light grey blobs circumscribed in white indicate regions fixated significantly more by LRP participants ($Z_{crit} = 4.25$; $p < .001$), with the dark grey blobs circumscribed in black showing regions significantly fixated more by HRP participants ($Z_{crit} = -4.25$; $p < .001$).

The results of the iMap analysis clearly show HRP individuals (implicit or explicit) have a significantly different fixation bias pattern when compared to LRP participants. Regarding the differences between *implicit* HRP and LRP groups (Figure 3, top panels), HRP participants exhibited a statistically significant fixation bias pattern focused on the region between the eyes, but this difference was present regardless of face race. On the other hand, implicit LRP participants exhibited a significant fixation bias pattern focused on the mouth, regardless of face race. As a follow-up analysis, we examined the extent to which the fixation bias patterns mentioned above (and illustrated in Figure 3) correlated with IAT-weighted fixation maps. IAT-weighted fixation maps were generated by weighting each participant's fixation within the across-participant heat map with their corresponding IAT score. The result was then convolved with the difference maps used to create Figure 3 using a cross-correlation function and a convolution window consisting of 100×100 pixels. The coefficients within the significant regions shown in Figure 3 were then averaged. The region between the eyes yielded an average $R^2 = 0.56$ ($SD = .10$), $p < 1e^{-20}$ for HRP participants viewing White faces, and $R^2 = 0.47$ ($SD = .11$), $p < 1e^{-20}$ for HRP participants viewing Black faces. The mouth region yielded an average $R^2 = 0.51$ ($SD = .05$), $p < 1e^{-20}$ for LRP participants viewing White faces, and $R^2 = 0.36$ ($SD = .14$), $p < 1e^{-20}$ for LRP participants viewing Black faces.

Regarding the *explicit* racial prejudice results, the target's eyes show the same trend observed between the implicit prejudice groups, but explicit HRP participants produced a prominent bias at the mouth region for the Black face stimulus set but not for White faces (Figure 3 bottom panels). Using the same cross-

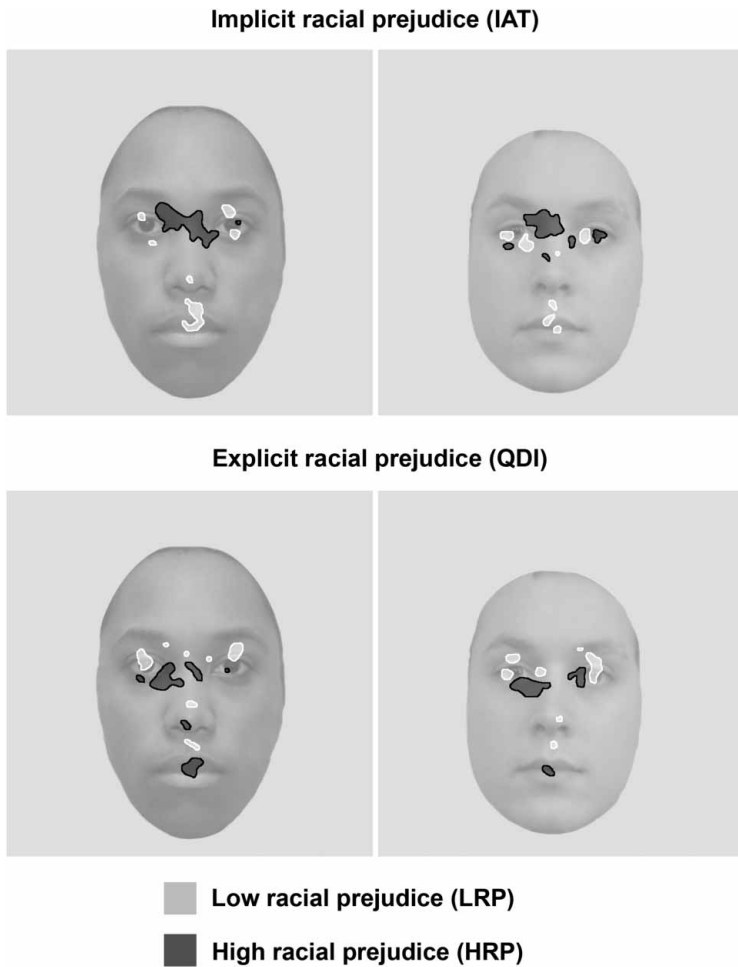


Figure 3. Patterned fixation bias maps for both measures of racial prejudice for Black (left column) and White (right column) faces. For clarity, only the statistically significant Z-scored duration and prejudice level-weighted bias ($Z_{crit} = |4.25|$; $p < .001$) fixations are shown. Dark grey regions circumscribed in black show fixation locations viewed significantly more by HRP participants. Light grey regions circumscribed in white show fixation locations viewed significantly more by LRP participants. The data have been superimposed on reference faces that were generated using FantaMorph (version 4) to morph all faces within the Black face condition (i.e., a morphed “average”) on the left and all faces within the White face condition on the right.

correlation analysis described above (but with QDI-weighted fixation maps), the mouth region yielded an average $R^2 = 0.13$ ($SD = .03$), $p < 1e^{-20}$ for HRP participants viewing White faces and, crucially, $R^2 = 0.61$ ($SD = .02$), $p < 1e^{-20}$ for HRP participants viewing Black faces.

To sum up so far, implicit HRP participants exhibit a significant tendency to fixate on the region between the eyes, while implicit LRP participants yielded a significant tendency to fixate on the mouth region. However, the implicit HRP bias was not specific to Black target faces: the same bias was present in the White face stimulus set. On the other hand, explicit HRP participants produced a large significant fixation bias within the mouth region of Black faces. Further, the fixation bias patterns were different for implicit HRP participants compared to explicit HRP participants. As a supplementary test of the generality of the implicit prejudice biases and the specificity of the explicit prejudice biases, we ran the iMap analysis on our Asian face stimulus set. It is important to note that while the QDI allows for differences between explicit LRP and HRP participants to be attributed to generalized prejudice against ethnic minorities, our implicit measure was only designed to test for White-Black prejudice and thus differences in fixation biases between LRP and HRP participants with Asian targets can only be attributed to general differences between high and low prejudiced individuals and not to anti-Asian prejudice per se. The results of the iMap analysis are shown in [Figure 4](#).

The results of the Asian face analysis show that implicit HRP participants again demonstrate a statistically significant fixation bias to the region between the eyes, whereas the explicit HRP participants do not show a statistically significant fixation bias to the mouth. We will address the implications of these findings in the Discussion section.

Finally, while it was not the focus of the current study, we also examined bias maps produced by face stimuli within each stimulus race set as a function of stimulus gender (e.g., Black female faces, Black male faces, White female

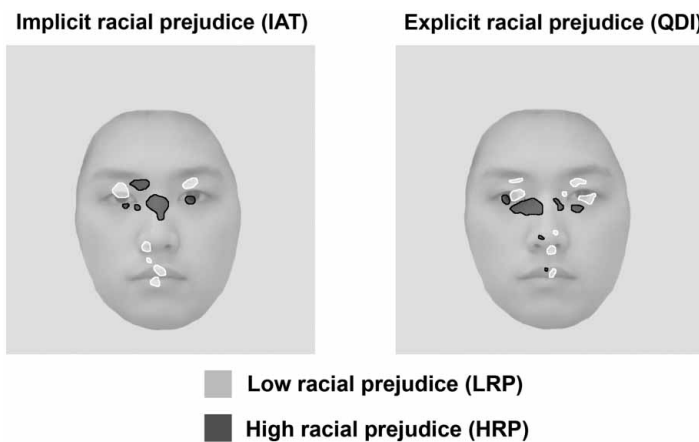


Figure 4. Patterned fixation bias maps for both measures of racial prejudice for Asian faces. The layout and format of the maps is identical to that described in [Figure 3](#).

faces, and White male faces) and found results that were virtually identical to those reported in [Figure 3](#)). It would also be interesting to run the above analysis as a function of participant gender, but the design of the current study did not allow examining such gender effects.

Fixation pattern biases across time

To answer our second broad question concerning whether fixation differences vary as a function of prejudice across the viewing window, we set out to explore the LRP and HRP fixation bias pattern maps during different time windows across the majority of the trial viewing period in order to determine *when* the fixation biases discussed above occurred. In addition to revealing differences by prejudice level across time, this analysis can also reveal whether implicit and explicit prejudice is expressed through eye movements during different windows of time. We therefore repeated the same procedures for constructing the fixation bias maps used to construct [Figure 3](#), except that those procedures were applied to fixation data that fell within three sequential two-second intervals (e.g., 0–2, 2–4, and 4–6 seconds of trial viewing time, see [Pannasch et al., 2008](#)). The results of the iMap analysis are shown in [Figure 5](#). Starting first with the *implicit* prejudice bias maps (i.e., [Figure 5A](#)), the HRP tendency to fixate the region between the eyes is present within the first two seconds of viewing (regardless of face race) and persists into the 2–4 second time bin (which is more apparent in the White face stimulus set). It therefore appears that the between-the-eyes bias is an early viewing strategy taken by HRP participants that is prominent within the first two seconds of face viewing time and lasts up to four seconds. What also arises from the current analysis is that the nose of the Black face stimulus set is fixated more prominently by HRP weighted participants than LRP participants within the first two seconds of viewing time and gives way to an almost complete reversal within the 2–4 second viewing period. Lastly, virtually no prejudice specific fixation biases are evident in the 4–6 second viewing period. Thus, the HRP bias observed in [Figure 3](#) (top row) are expressed very early in the viewing period (within the first two seconds) and persisted for up to four seconds of viewing time. Additionally, a face race specific effect is observed by HRP participants in that the nose of the Black face set was fixated much more prominently within the first two seconds only.

Regarding the *explicit* time-resolved prejudice bias maps (i.e., [Figure 5B](#)), the tendency for HRP participants to fixate the mouth region for the Black face stimulus set is present within the first two seconds of viewing time and persists across the rest of stimulus duration. This suggests that it is a viewing bias that is early and stable for lengthy durations. The modest between-the-eyes region bias for Black face stimuli is not prominent during any of the temporal windows, suggesting it was a bias that was gradually built up across the entire viewing session. Lastly, as in the implicit prejudice temporal analysis, there is a tendency for explicit

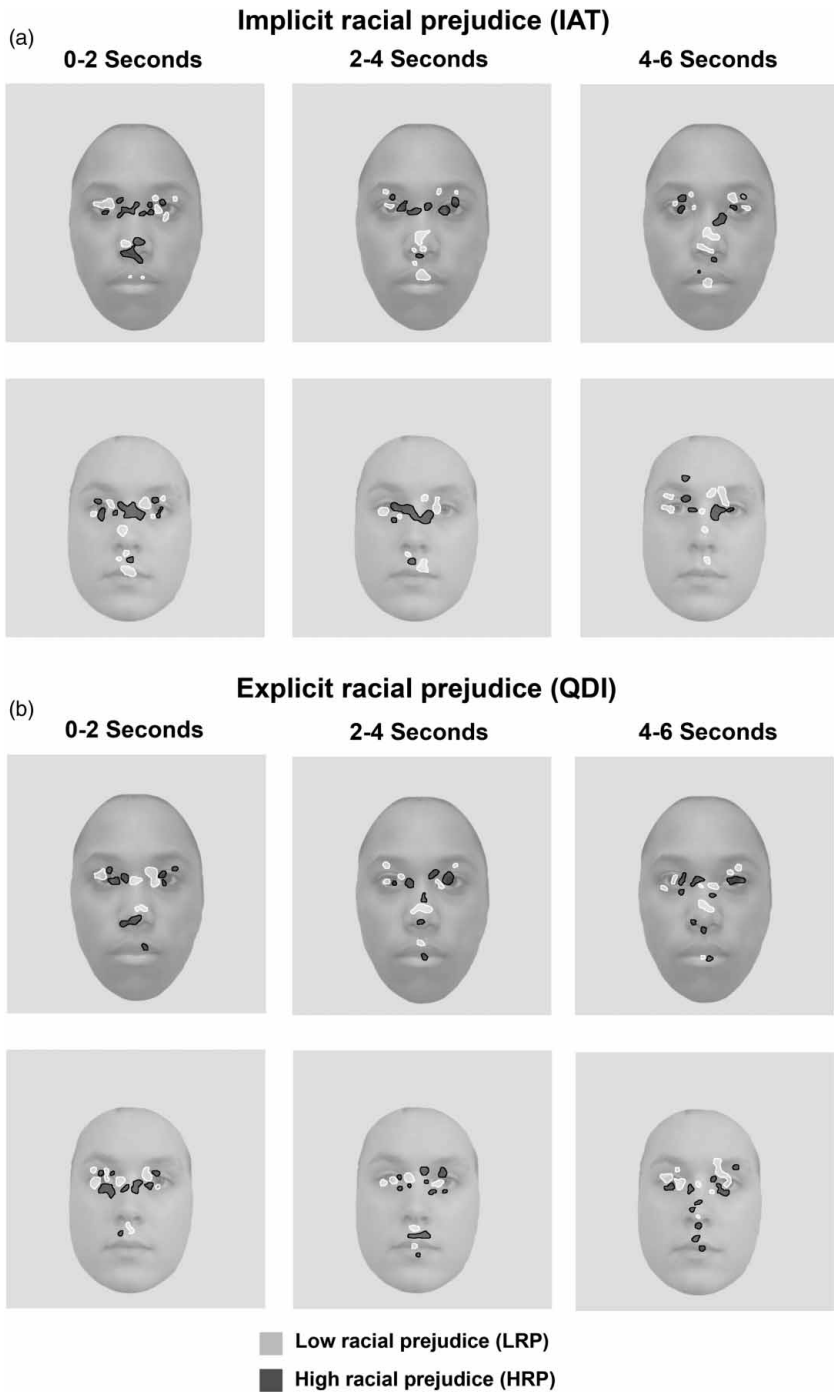


Figure 5. Patterned fixation bias maps for both measures of racial prejudice during three sequential two-second trials viewing periods. The layout and format of the maps is identical to that described in [Figure 3](#).

HRP participants to fixate the nose of the Black face stimulus set in the first two seconds, with HRP participants producing a nose region bias. Thus, the HRP mouth bias for Black faces observed in Figure 3 (bottom row) is expressed very early in the viewing period (within the first two seconds), with an additional bias to more prominently fixate the nose in the first two seconds of viewing time. We will return to the implications of these findings in the Discussion section.

Consistency of scanning sequences within race: Comparison for spatio-temporal similarity (ScanMatch analysis)

The third and last major question we explored concerned whether there are any significant differences in how participants varying in either implicit or explicit prejudice sequentially fixate Black faces: whether racial prejudice influences the consistency of the pattern one follows when viewing different images of Black faces. To do this, we submitted participant eye-tracking data to the ScanMatch analysis described in the Method section. Since the iMap analysis showed similarities in regional fixation biases between Black faces and White faces, we also submitted the White face dataset to the ScanMatch analysis. The obtained similarity scores were entered into a 2 (prejudice type: explicit, implicit) \times 2 (face race: Black, White) \times 2 (prejudice level: low, high) mixed effects repeated measures analysis of variance (ANOVA) with prejudice type and face race serving as within-subjects factors and prejudice level serving as the between-subjects factor. The results yielded significant main effects for face race, $F(1,14) = 4.59$, $p = .05$, revealing a higher similarity for White faces. There was also a main effect for prejudice group, $F(1,14) = 9.10$, $p < .01$, such that scanning similarity was larger for subjects with a low level prejudice, but no significant main effect for prejudice type, $F(1,14) = 2.95$, $p = .108$. However, this was qualified by a significant interaction of prejudice type \times prejudice level, $F(1,14) = 11.30$, $p < .001$ (Figure 6C). That is, when scan pattern similarity is split by the level of prejudice (i.e., low vs. high), there are larger differences between explicit LRP and HRP participants (see Figure 6B), with virtually no difference between implicit HRP and LRP participants (across stimulus face race, see Figure 6A). Thus, low explicit prejudice, low implicit prejudice, and high implicit prejudice participants all exhibited consistent viewing patterns irrespective of target race, whereas high explicit prejudice participants appeared less consistent in the way they scan faces, again irrespective of target race. The generality of this finding was confirmed by comparing (independent samples *t*-test) explicit HRP and LRP participants for the Asian face trials: scanning similarity was again higher for low level prejudice participants ($p < .01$).

In order to examine the prejudice type \times prejudice level interaction with respect to stimulus face race, post-hoc two-way mixed effects ANOVAs were run on the prejudice type \times prejudice level interaction separately for each stimulus face race.

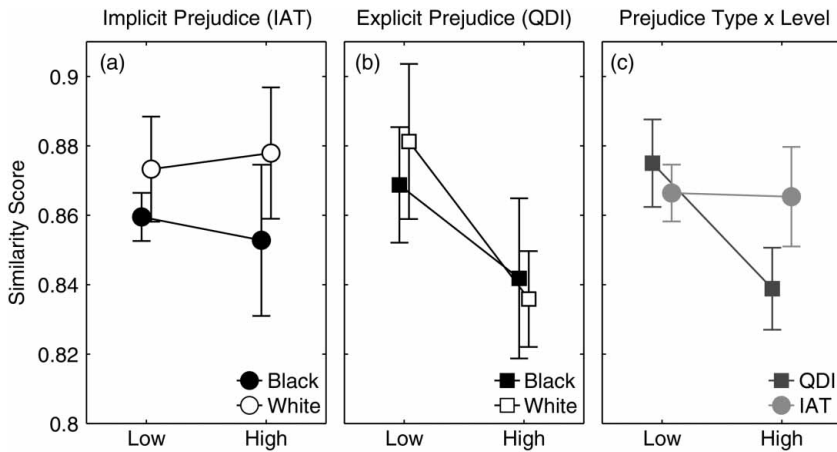


Figure 6. Similarity of viewing behaviour for participants with implicit (A) and explicit (P) LRP and HRP. The interaction of prejudice type (implicit vs. explicit) and level (low vs. high) is shown in panel C. The error bars represent 95% confidence intervals.

The results of the post-hoc ANOVAs yielded interactions that trended toward significance for Black faces, $F(1,14) = 4.21$, $p = 0.05$, $\eta^2 = 0.231$, and reached significance for White faces $F(1,14) = 8.15$, $p < 0.05$, $\eta^2 = 0.368$. Accordingly, the interaction supports the notion that prejudice type and prejudice level may lead to differences in face scanning behaviour.

It therefore seems that while our explicit HRP participants employed a determined fixation region bias when viewing Black faces (e.g., the mouth region), they engage in less consistent scanning sequences regardless of face race: they are relatively less consistent in scanning faces in general.

Patterned fixation biases for different prejudice sub-types

Having explored our major questions concerning how prejudice influences the viewing of Black target faces, we conducted supplemental analyses concerning fixation biases as a function of different combinations of implicit and explicit bias (e.g., “aversive racists” who are known to harbour implicit biases while disavowing any bias explicitly; Dovidio & Gaertner, 1998). We therefore grouped participants into four separate quadrants based on the IAT and QDI scores (as shown in Figure 2: splitting by the median IAT and QDI score), which resulted in sample sizes of: $n = 19$ for the bottom left quadrant (“low” implicit and “low” explicit prejudice); $n = 15$ for the top left quadrant (“low” implicit and “high” explicit prejudice); $n = 17$ for the top right quadrant (“high” implicit and “high” explicit prejudice); and $n = 17$ for the bottom right quadrant (“high”

implicit and “low” explicit prejudice). Grouping participants in this way allowed for six comparisons in total. Note that we set our iMap analysis to only identify regions fixated differently (i.e., LRP vs. HRP) at $p < 0.001$, which falls below the 0.05 Bonferroni corrected p -value of 0.008 for multiple comparisons. Participant duration-weighted heat maps and statistically validated difference maps (i.e., patterned duration-weighted fixation bias maps) were created in an identical manner as described previously, with the following exceptions: (1) only participants with IAT and QDI scores falling within one particular prejudice space quadrant were included in a set of heat maps; and (2) statistically validated difference maps were constructed by differencing Black and White stimulus set heat maps across two quadrants, within race (e.g., differencing low implicit/low explicit quadrant from high implicit/high explicit quadrant for both White faces and Black faces separately). Of the six quadrant comparisons, only three yielded statistically significant bias regions by one quadrant or the other ($Z_{\text{crit}} = -4.25$; $p < .001$). For the sake of simplicity we therefore only report the results from those quadrant comparisons (Figure 7).

The top panel of Figure 7 shows the resulting statistically validated bias maps for participants who scored high on both the IAT and QDI (top right quadrant of prejudice space) compared to participants who scored low on both the IAT and QDI. Thus, when examining the bias maps for “overall” prejudice (low implicit/explicit vs. high implicit/explicit), HRP participants exhibit a between-the-eyes fixation bias and LRP participants exhibit an eyes and mouth fixation bias (again, regardless of stimulus face race). This is exactly the same pattern observed in the top panel of Figure 3 (implicit measure duration-weighted bias maps from all participants). Interestingly, a similar bias pattern is observed in the middle panel of Figure 7 (low implicit/explicit vs. high implicit/low explicit). The bottom panel of Figure 7 (low implicit/explicit vs. low implicit/high explicit), however, shows the mouth bias for the Black face stimulus set observed in the bottom panel of Figure 3 (explicit measure duration-weighted bias maps from all participants). Thus, the quadrants of the prejudice space that are likely producing the between-the-eyes fixation bias come from referencing minimally prejudiced participants (low in both implicit and explicit prejudice) to any other quadrant in that space (i.e., high in implicit, explicit, or both). However, the mouth bias for the Black face stimulus set appears to be localized within the left two quadrants (i.e., low implicit and explicit vs. low implicit/high explicit). In other words, it appears that high explicit prejudice drives the tendency to fixate on the mouth region of Black faces, whereas high prejudice of any type may account for a lower probability to fixate the eyes of Black, as well as White faces. We will return to the implications of these findings in the Discussion section.

In order to provide a more traditional representation of the data shown in Figures 3–5 and 7, we ran an analysis of the duration-weighted fixation frequencies within traditional ROIs (entire eye region, entire nose region, etc.) that

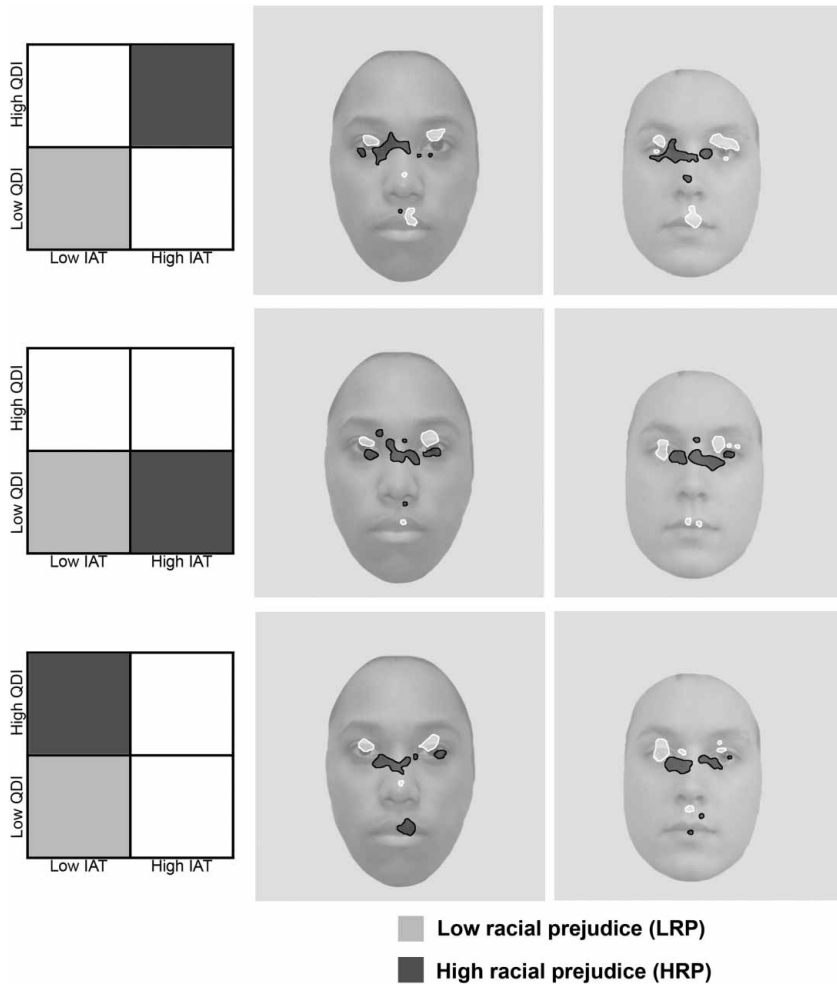


Figure 7. Patterned fixation bias maps created by subtracting duration-weighted heat maps from two prejudice space quadrants for Black (left column) and White (right column) faces. The layout and format of the maps is identical to that described in Figure 3. The schematic boxes to the left indicate from which prejudice space quadrant the comparisons were made. Heat maps from the dark grey quadrants (HRP for implicit, explicit, or both) were always subtracted from the light grey quadrant heat maps (LRP for both implicit and explicit prejudice). That is, for the top panel, HRP implicit and explicit heat maps were subtracted from LRP implicit and explicit. For the middle panel, HRP impact/LRP explicit was subtracted from LRP implicit and explicit. Lastly, for the bottom panel, HRP explicit/LRP implicit was subtracted from LRP implicit and explicit.

contained statistically significant differences as indicated by the iMap analyses reported above. The results of those analyses were virtually identical to the iMap analysis results, and are reported as Supplementary Material.

DISCUSSION

The current study set out to explore whether human participants varying in their level and type of racial prejudice would exhibit different exploratory looking behaviours when examining Black faces. Specifically, we were interested in establishing: (1) whether there would be different exploratory fixation behaviours between individuals classified as either low or high in racial prejudice (as well as between individuals classified as possessing high implicit or explicit prejudice); (2) whether such differences would vary across viewing time; and (3) whether prejudice influences the consistency with which one scans different exemplars of Black faces. The results revealed that individuals higher in racial prejudice exhibited exploratory looking behaviour differences that were specific not only to level of prejudice, but also prejudice type (i.e., implicit vs. explicit). Specifically, individuals high in explicit racial prejudice were more likely to fixate on the mouth region of Black faces (compared to low explicitly prejudiced individuals), and this bias was observed within the first two seconds of viewing time and persisted across the entire viewing duration. The ScanMatch analysis revealed that explicit HRP participants exhibited less consistency in the way they visually scan Asian, Black, or White faces when compared to explicit LRP participants (and implicit LRP and HRP participants). On the other hand, individuals high in implicit racial prejudice were more likely to fixate on the region between the eyes, whereas those low in implicit prejudice focused more on the mouth region. However, a similar trend in fixation bias was observed for White faces, as well as Asian faces (but note the caveats raised earlier for the Asian face set analysis). Additionally, the tendency for implicit HRP participants to fixate the region between the eyes was observed within the first two seconds of viewing time, and persisted through four seconds, but was absent in the later two seconds of viewing time. Finally, the ScanMatch analysis did not yield any significant differences related to how implicit LRP or HRP participants scanned faces of any race.

One of the more interesting facets of this study comes from the pattern bias iMap analysis which showed a tendency for *explicitly* HRP individuals to exhibit a prominent fixation bias at the mouth for Black faces. Additionally, the mouth region bias appeared as early as the first two seconds of viewing time and persisted across almost the entire viewing period for Black face stimuli. This region bias is interesting to note because the mouth region (lips in particular), has been identified by previous research as a region that stereotypically differentiates Blacks from other racial groups (e.g., Blair, Judd, & Chapleau, 2004; Eberhardt, Davies, Purdie-Vaughns, & Johnson, 2006). Further, the lower likelihood to fixate stereotypic features by individuals lower in prejudice is consistent with evidence that motivation can influence automatic stereotyping and perception (e.g., Balcetis & Dunning, 2006; Sinclair & Kunda, 1999), and adds an important

caveat to the view that stereotyping is automatic and *uncontrollable among both low and high prejudice individuals alike* for processes that mostly occur outside of conscious control, such as visual perception (Devine, 1989; Bargh, Chen, & Burrows, 1996), since *only* high prejudice individuals in the current studies exhibited this “mouth bias”. Additionally, the mouth bias was not observed for Asian faces, and was much smaller in terms of area covered for White faces, further suggesting that fixation on the mouth among explicitly prejudiced participants was a function of stereotypic processing. Nevertheless, we must interpret this finding with some caution, as the mouth region bias (Figure 3) was mostly produced by participants who were low in implicit prejudice but high in explicit prejudice (Figure 7).

Conversely, the pattern bias iMap analysis for *implicit* prejudice was mixed. That is, while implicit HRP participants focused more on the region between the eyes when compared to implicit LRP participants, that difference was observed regardless of target race (e.g., Asian, Black, or White face stimuli). Moreover, that bias was observed to take place starting within the first two seconds of viewing time, persisted up to four seconds, and did not require the addition of explicit prejudice. Thus, while we did observe a significant difference in the fixation pattern biases between implicit LRP and HRP participants, that difference was not specific to any of the face races we examined here. The lack of a difference in fixation bias across face race may have resulted from our single face presentation paradigm. That is, recent work by Kawakami and colleagues (2014) argues that intergroup context stimulus paradigms (i.e., two different race faces presented side-by-side) may make for a more salient stimulus scenario, thereby increasing the likelihood to find fixation differences at critical facial features. One possible extension of the current study would be to examine the role of racial prejudice when viewing faces in an intergroup context. An alternative possibility may be that the IAT is not sensitive enough to detect differences in fixation behaviour, as indicated by the current debate surrounding its small effect size to predict a wide variety of prejudiced behaviours (e.g., Oswald, Mitchell, Blanton, Jaccard, & Tetlock, 2013, 2015; but see Greenwald, Banaji, & Nosek, 2015, on the effect of selection criteria on effect size estimates and on the potential societal importance of small effects). Nevertheless, the tendency of implicit HRP participants to fixate the region between the eyes is compelling in its consistency across several face races, and in its contrast to the mouth region bias observed with explicit HRP participants.

It is worth noting that the statistical tendency of implicit HRP participants to exhibit similarities in fixation patterns across stimulus race do bear some resemblance to a similar tendency of participants to exhibit fixation pattern consistencies across stimulus race recently reported in the own-race-bias literature (e.g., Blais et al., 2008; Caldara et al., 2010; Hills & Pake, 2013; but see Fu, Hu, Wang, Quinn, & Lee, 2012; Goldinger, He, & Papesh, 2009; Kawakami, et al., 2014, Experiment 3; Wu, Laeng, & Magnussen, 2012). It is important to note that the

patterns we observe here (e.g., bias to the region between the eyes) and those recently reported in the own-race-bias literature are not the same, and we would not expect them to be, as our participants engaged in free-viewing and were grouped according to racial prejudice. Further, since we did not have a recognition task (which would recruit fixations indicative of encoding processes for later recognition), we cannot directly connect our current results to the own-race-bias. However, it's still interesting to note that the tendency to take on a consistent viewing strategy regardless of face race has been observed before. Hills and Pake (2013) suggest that such a strategy, in an own-race bias context (and in the absence of measured prejudice), may reflect the internal representation of faces as it relates to the face-space model proposed by Valentine and colleagues (i.e., Valentine, 1991; Valentine & Endo, 1992), a model that has gained significant support in the face adaptation literature (see Webster & Macleod, 2011 for a review). As Hills and Pake (2013) note, such a model would predict the use of facial features that allow for efficient discrimination between encountered faces, and recent eye-tracking studies in face perception have argued that fixations around but not directly on the eyes may capture the most optimal cues for face recognition (e.g., Hsiao & Cottrell, 2008; Peterson & Eckstein, 2012). Thus, the between-the-eyes bias may allow for the integration of a larger number of face features (eyes, nose and mouth features), which would suggest that implicit HRP individuals utilize a more optimized strategy for face identification.

Conversely, the between-the-eyes bias could be indicative of implicit HRP individuals being generally less likely to initially engage (or process) others on an individual level (e.g., Frischen, Bayliss, & Tipper, 2007). That is, implicit HRP participants may be less concerned with features, such as the eyes, that are critical for individuating faces or engaging with others on a more personal level (e.g., Frischen et al., 2007; Kawakami et al., 2014; Kleinke, 1986; McKelvie, 1976; Sekuler, Caspar, Gold, & Bennett, 2004; Vinette, Gosselin, & Schyns, 2004), and might reflect that those individuals may take on a generalized face-as-object (as opposed to face as an individual) approach to visually exploring a given new face identity when first encountered.

A final account of the implicit HRP bias, not necessarily mutually exclusive from the above, is that previous research has established that prejudice is associated with lower levels of empathy (e.g., Stephan & Finlay, 1999). Thus, it is conceivable that reduced fixation of the features related to face identification by those high implicit in prejudice is mediated by empathy. While we do not have the data to test for the three accounts given above, all would be worthy targets for future research.

Although the accounts given above are intriguing, they should be interpreted with some caution, since fixation location and the direction of attention can be decoupled (e.g., Posner, 1980). Therefore, it is possible that implicit HRP individuals are overtly fixating on the area between the eyes while covertly directing attention to individuating features. However, given that our participants could

freely explore the faces, such a decoupling between fixation location and attention direction seems unlikely (e.g., Findlay & Gilchrist, 2003; Henderson, 2007). Free visual exploration, according to the active vision approach, involves covert as well as overt attention as integral parts of the active vision cycle when fixating items that are of interest. The fixation act means paying attention to the fixated region but is supported by covert processes such as peripheral preview for the next fixation location and the processing of global information from the periphery. Accordingly, covert and overt selection are intrinsically linked with the current fixation location as the main source of information. This seems reasonable because redirecting attention overtly by moving the gaze, rather than covertly, implies that the attended location obtains the immediate benefit of high-resolution foveal vision. Since eye movements are executed quickly and efficiently, it would not make sense to rely on covert attention shifts when eye movements are allowed. However, there is ample evidence that covert attention shifts are possible, but they require extra effort and are mostly provoked under experimental passive viewing conditions.⁴

Nevertheless, further research is needed to rule out this possibility, and to test the likelihood that implicit HRP individuals are fixating on the same region irrespective of target race in order to efficiently discriminate between members of different racial groups.

Regarding our time-resolved iMap analysis, we did not find clear separable temporal intervals for fixation pattern biases explained by either implicit or explicit prejudice. For instance, both the between-the-eyes and mouth fixation biases were observed within the first two seconds of viewing time. It therefore seems as though both types of prejudice can direct looking behaviour during a time scale when eye movements are known to be predominantly automated. While such a finding is not altogether surprising in the context of forms of prejudice associated with automated expression (i.e., implicit prejudice), it is not what one would expect for forms of prejudice traditionally associated with more controlled forms of prejudice such as explicit prejudice. However, as alluded to above, such a finding would be consistent with the notion that motivation can have an influence on automatic processing and may be expressed here by initially directing the eyes (and, thus, subsequent processing of the encountered visual information) towards a stereotypical feature of Black face stimuli. While the appearance of implicit and explicit prejudice fixation biases in the “automatic time window” for eye movements is not easily explained, the differences observed in the latter time windows do show some signs of what one would expect using an automatic vs. controlled prejudice framework. Specifically, while the between-

⁴In addition, even if decoupling of fixation and attention is occurring, due to the sampling of different face information implicit HRP and LRP individuals would differ regarding the visual information available overtime. Even the possibility of decoupling should not lead individuals with different levels of implicit prejudice to have the same visual information and behave similarly over time.

the-eyes bias persisted into the 2–4 second range, it was absent in the latest temporal window where the mouth bias was still observed. Further research is certainly needed to elucidate the relationship between automated and controlled types of prejudice and their possible expression through automated and voluntary eye movements.

Finally, the results of the ScanMatch analysis revealed that individuals high in explicit prejudice were unique in exhibiting less consistent sequence patterns in the way they scanned Black, as well as White faces relative to explicit LRP, implicit LRP, and implicit HRP participants. Put another way, explicit LRP and implicit LRP and HRP participants produced scanning sequences that may reflect that those individuals were more similarly guided to explore faces in a consistent manner in terms of *how* specific face information is brought into the system (eyes before mouth, mouth before nose, etc.), whereas explicit HRP participants are more varied with respect to their sequential fixation guidance strategy. Furthermore, this lower consistency in scanning strategy did not vary as a function of stimulus face race, and may therefore reflect differences within larger, more general, processing capabilities. For example, Hodson and Busseri (2012) recently reported evidence for a relationship between intelligence and explicit prejudice, whereby lower levels of general intelligence during childhood predicted higher levels of explicit racial prejudice during adulthood. What is interesting about that relationship is that selective overt attention, the type often linked to the direction of eye movements, is also known to be related to intelligence (e.g., lower levels of general intelligence being associated with lower levels of attentional control; Burns, Nettelbeck, & McPherson, 2009; Cowan, Fristoe, Elliot, Brunner, & Sauls, 2006; Schweizer, Moosbrugger, & Goldhammer, 2005), and mediates differences in information reanalysis and various cognitive interactions (e.g., Vandenberg, Bouwmeester, Bocanegra, & Zwaan, 2013; von der Malsburg & Vasisht, 2013). It may therefore be possible that the lower levels of scanning consistency that we observed in our explicit HRP participants reflects a lower level of general intelligence (or attentional control) on the part of those individuals, and is expressed through the deployment of intermittent reanalysis scanning sequences within the viewing duration. Since we did not measure general intelligence or attentional control capabilities in our study, we can only speculate on those variables as possible mediators of individual differences in scanning sequences. It would be interesting, as a follow up, to directly test the possibility that general intelligence mediates the effect of prejudice on attentional control.

To conclude, the current study found that explicit prejudice may increase the likelihood of focusing on stereotypic facial features (e.g., the lips of Black targets) and exhibit a decrease in scanning consistency across face race. The results also show that while implicitly prejudiced individuals were more likely to fixate the region between the eyes when compared to individuals low in implicit prejudice, that strategy was not specific to any face race. Although additional research will no doubt shed light on additional mediators of these phenomena,

such as a differential use of an internalized face space, the exact degree of involvement of automated vs. voluntary processes strategies, relative levels of empathy, or differences in attentional control and general intelligence, the current findings contribute to our understanding of how racial prejudice may bias visual processing in such a way that may reinforce stereotypes and facilitate dehumanization.

Supplementary material

Supplementary (Figure 1/content) is available via the Supplemental data for this article can be accessed here [<http://dx.doi.org/10.1080/13506285.2015.1063554>]

REFERENCES

- Balcetis, E., & Dunning, D. (2006). See what you want to see: Motivational influences on visual perception. *Journal of Personality and Social Psychology, 91*, 612–625.
- Bargh, J. A., Chen, M., & Burrows, L. (1996). Automaticity of social behavior: Direct effects of trait construct and stereotype activation on action. *Journal of personality and social psychology, 71*, 230.
- Bean, M., Slaten, D., Horton, W., Murphy, M., Todd, A., & Richeson, J.A. (2012). Prejudice concerns and race-based attentional bias: New evidence from eyetracking. *Social Psychological and Personality Science, 3*, 722–729. doi:10.1177/1948550612436983
- Blair, I. V., Judd, C. M., & Chapleau, K. M. (2004). The influence of Afrocentric facial features in criminal sentencing. *Psychological Science, 15*, 674–679.
- Blais, C., Jack, R. E., Scheepers, C., Fiset, D., & Caldara, R. (2008). Culture shapes how we look at faces. *Plos One, 3*, e3022. doi:10.1371/journal.pone.0003022.s004
- Borji, A., & Itti, L. (2014). Defending Yarbus: Eye movements reveal observers' task. *Journal of Vision, 14*(3), 29. doi:10.1167/14.3.29
- Burns, N. R., Nettelbeck, T., & McPherson, J. (2009). Attention and intelligence: A factor analytic study. *Journal of Individual Differences, 30*, 44–57.
- Caldara, R., & Miellet, S. (2011). IMap: A novel method for statistical fixation mapping of eye movement data. *Behavior Research Methods, 43*, 864–878. doi:10.3758/s13428-011-0092-x
- Caldara, R., Zhou, X., & Miellet, S. (2010). Putting culture under the 'spotlight' reveals universal information use for face recognition. *PLoS One, 5*, e9708. doi:10.1371/journal.pone.0009708.s002
- Callan, M. J., Ferguson, H. J., & Bindemann, M. (2013). Eye movements to audiovisual scenes reveal expectations of a just world. *Journal of Experimental Psychology: General, 142*(1), 34–40. doi:10.1037/a0028261
- Chauvin, A., Worsley, K. J., Schyns, P. G., Arguin, M., & Gosselin, F. (2005). Accurate statistical tests for smooth classification images. *Journal of Vision, 5*, 659–667.
- Cowan, N., Fristoe, N. M., Elliot, E. M., Brunner, R. P., & Sauls, J. S. (2006). Scope of attention, control of attention, and intelligence in children and adults. *Memory & Cognition, 34*, 1754–1768. doi:10.3758/BF03195936
- Cristino, F., Mathôt, S., Theeuwes, J., & Gilchrist, I. D. (2010). ScanMatch: A novel method for comparing fixation sequences. *Behavior Research Methods, 42*, 692–700. doi:10.3758/BRM.42.3.692
- Cunningham, W. A., Johnson, M. K., Raye, C. L., Gatenby, J. C., Gore, J. C., & Banaji, M. R. (2004). Separable neural components in the processing of black and white faces. *Psychological Science, 15*, 806–813. doi:10.1111/j.0956-7976.2004.00760.x

- Devine, P. G. (1989). Stereotypes and prejudice: Their automatic and controlled components. *Journal of Personality & Social Psychology*, 56(1), 5–18. doi:10.1037/0022-3514.56.1.5
- Dotsch, R., Wigboldus, D. H. J., Langner, O., & van Knippenberg, A. (2008). Ethnic out-group faces are biased in the prejudiced mind. *Psychological Science*, 19, 978–980. doi:10.1111/j.1467-9280.2008.02186.x
- Dovidio, J. F., & Gaertner, S. L. (1998). On the nature of contemporary prejudice: The causes, consequences, and challenges of aversive racism. In J. L. Eberhardt & S. T. Fiske (Eds.), *Confronting Racism: The problem and the response* (pp. 3–32). Thousand Oaks, CA: Sage.
- Dovidio, J. F., Kawakami, K., Johnson, C., Johnson, B., & Howard, A. (1997). On the nature of prejudice: Automatic and controlled processes. *Journal of Experimental Psychology*, 33, 510–540.
- Eberhardt, J. L., Davies, P. G., Purdie-Vaughns, V. J., & Johnson, S. L. (2006). Looking deathworthy: Perceived stereotypicality of black defendants predicts capital-sentencing outcomes. *Psychological Science*, 17, 383–386. doi:10.1111/j.1467-9280.2006.01716.x
- Findlay, J. M., & Gilchrist, I. D. (2003). *Active vision: The psychology of looking and seeing*. Oxford: Oxford University Press.
- Fischer, T., Graupner, S. T., Velichkovsky, B. M., & Pannasch, S. (2013). Attentional dynamics during free picture viewing: Evidence from oculomotor behavior and electrocortical activity. *Frontiers in Systems Neuroscience*, 7, 17. doi:10.3389/fnsys.2013.00017
- Frischen, A., Bayliss, A. P., & Tipper, S. P. (2007). Gaze cuing of attention: Visual attention, social cognition, and individual differences. *Psychological Bulletin*, 133, 694–724. doi:10.1037/0033-2909.133.4.694
- Friston, K., Adams, R. A., Perrinet, L., & Breakspear, M. (2012). Perceptions as hypotheses: Saccades as experiments. *Frontiers in Psychology*, 3, 151. doi:10.3389/fpsyg.2012.00151. eCollection 2012
- Fu, G., Hu, C. S., Wang, Q., Quinn, P. C., & Lee, K. (2012). Adults scan own- and other-race faces differently. *PLoS One*, 7, e37688. doi:10.1371/journal.pone.0037688.t006
- Goldinger, S. D., He, Y., & Papesh, M. H. (2009). Deficits in cross-race face learning: Insights from eye movements and pupillometry. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 35, 1105–1122. doi:10.1037/a0016548
- Greenwald, A. G., & Banaji, M. R. (1995). Implicit social cognition: Attitudes, self-esteem, and stereotypes. *Psychological Review*, 102(1), 4–27. doi:10.1037/0033-295X.102.1.4
- Greenwald, A. G., Banaji, M. R., & Nosek, B. A. (2015). Statistically small effects of the implicit association test can have societally large effects. *Journal of Personality and Social Psychology*, 108, 553–561. doi:10.1037/pspa0000016
- Greenwald, A. G., McGhee, D. E., & Schwartz, J. L. K. (1998). Measuring individual differences in implicit cognition: The implicit association test. *Journal of Personality and Social Psychology*, 74, 1464–1480. doi:10.1037/0022-3514.74.6.1464
- Greenwald, A. G., Nosek, B. A., & Banaji, M. R. (2003). Understanding and using the implicit association test: I. An improved scoring algorithm. *Attitudes and Social Cognition*, 85, 197–216.
- Gregory, R. L. (1980). Perceptions as hypotheses. *Philosophical Transactions of the Royal Society of London B*, 290, 181–197. doi:10.1098/rstb.1980.0090
- Hannula, D. E., Althoff, R. R., Warren, D. E., Riggs, L., Cohen, N. J., & Ryan, J. D. (2010). Worth a glance: Using eye movements to investigate the cognitive neuroscience of memory. *Frontiers in Human Neuroscience*, 4, 166. doi:10.3389/fnhum.2010.00166
- Hayhoe, M. M., & Ballard, D. H. (2005). Eye movements in natural behavior. *Trends in Cognitive Sciences*, 9, 188–194. doi:10.1016/j.tics.2005.02.009
- Henderson, J. M. (2007). Regarding scenes. *Current Directions in Psychological Science*, 16, 219–222. doi:10.1111/j.1467-8721.2007.00507.x
- Henderson, J. M., & Pierce, G. L. (2008). Eye movements during scene viewing: Evidence for mixed control of fixation durations. *Psychonomic Bulletin & Review*, 15, 566–573. doi:10.3758/PBR.15.3.566

- Henderson, J. M., Williams, C. C., & Falk, R. J. (2005). Eye movements are functional during face learning. *Memory & Cognition*, 33(1), 98–106. doi:10.3758/BF03195300
- Hills, P. J., & Pake, J. M. (2013). Eye-tracking the own-race bias in face recognition: Revealing the perceptual and socio-cognitive mechanisms. *Cognition*, 129, 586–597.
- Hodson, G., & Busseri, M. A. (2012). Bright minds and dark attitudes: Lower cognitive ability predicts greater prejudice through right-wing ideology and low intergroup contact. *Psychological Science*, 23, 187–195. doi:10.1177/0956797611421206
- Holmqvist, K., Nystrom, M., Andersson, R., Dewhurst, R., Jarodzka, H., & Van De Weijer, J. (2011). *Eye tracking a comprehensive guide to methods and measures*. Oxford: Oxford University Press.
- Horry, R., & Wright, D. B. (2009). Anxiety and terrorism: Automatic stereotypes affect visual attention and recognition memory for White and Middle Eastern faces. *Applied Cognitive Psychology*, 23, 345–357. doi:10.1002/acp.1465
- Hsiao, J. H.-W., & Cottrell, G. (2008). Two fixations suffice in face recognition. *Psychological Science*, 19, 998–1006. doi:10.1111/j.1467-9280.2008.02191.x
- Hugenberg, K., & Bodenhausen, G. V. (2003). Facing prejudice: Implicit prejudice and the perception of facial threat. *Psychological Science*, 14, 640–643. doi:10.1046/j.0956-7976.2003.psci_1478.x
- Hugenberg, K., & Bodenhausen, G. V. (2004). Ambiguity in social categorization. The role of prejudice and facial affect in race categorization. *Psychological Science*, 15, 342–345. doi:10.1111/j.0956-7976.2004.00680.x
- Ito, T. A. & Bartholow, B. D. (2009). The neural correlates of race. *Trends in Cognitive Sciences*, 13, 524–531. doi:10.1016/j.tics.2009.10.002
- Janik, S. W., Wellens, A. R., Goldberg, M. L., & Dell'Osso, L. F. (1978). Eyes as the center of focus in the visual examination of human faces. *Perceptual & Motor Skills*, 47, 857–858. doi:10.2466/pms.1978.47.3.857
- Kawakami, K., Williams, A., Sidhu, D., Choma, B. L., Rodriguez-Bailón, R., Cañadas, E., ... Hugenberg, K. (2014). An eye for the I: Preferential attention to the eyes of ingroup members. *Journal of Personality and Social Psychology*, 107(1), 1–20. doi:10.1037/a0036838
- Kayser, C., Nielsen, K. J., & Logothetis, N. K. (2006). Fixations in natural scenes: Interaction of image structure and image content. *Vision Research*, 46, 2535–2545. doi:10.1016/j.visres.2006.02.003
- Kleinke, C. L. (1986). Gaze and eye contact: A research review. *Psychological Bulletin*, 100(1), 78–100. doi:10.1037/0033-2909.100.1.78
- Land, M. F. (2009). Vision, eye movements, and natural behavior. *Visual Neuroscience*, 26(1), 51–62. doi:10.1017/S0952523808080899
- Malcolm, G. L., & Henderson, J. M. (2010). Combining top-down processes to guide eye movements during real-world scene search. *Journal of Vision*, 10(2), 4.1–11. doi:10.1167/10.2.4
- McKelvie, S. J. (1976). The role of eyes and mouth in the memory of a face. *The American Journal of Psychology*, 89, 311–323. doi:10.2307/1421414
- Meissner, C. A., & Brigham, J. C. (2001). Thirty years of investigating the own-race bias in memory for faces: A meta-analytic review. *Psychology, Public Policy, & Law*, 7, 3–35.
- Miellat, S., Lao, J., & Caldara, R. (2014). An appropriate use of iMap produces correct statistical results: A reply to McManus (2013) “iMAP and iMAP2 produce erroneous statistical maps of eye-movement differences”. *Perception*, 43, 451–457.
- Needleman, S. B., & Wunsch, C. D. (1970). A general method applicable to the search for similarities in the amino acid sequence of two proteins. *Journal of Molecular Biology*, 48, 443–453. doi:10.1016/0022-2836(70)90057-4
- Nosek, B. A. (2005). Moderators of the relationship between implicit and explicit evaluation. *Journal of Experimental Psychology: General*, 134, 565–584.

- Oswald, F. L., Mitchell, G., Blanton, H., Jaccard, J., & Tetlock, P. E. (2013). Predicting ethnic racial discrimination: A meta-analysis of IAT criterion studies. *Attitudes & Social Cognition*, *105*, 171–192.
- Oswald, F. L., Mitchell, G., Blanton, H., Jaccard, J., & Tetlock, P. E. (2015). Using the IAT to predict ethnic and racial discrimination: Small effect sizes of unknown societal significance. *Journal of Personality & Social Psychology*, *108*(4), 562–571.
- Pannasch, S., Helmert, J. R., Roth, K., Herbold, A.-K., & Walter, H. (2008). Visual fixation durations and saccadic amplitudes: Shifting relationship in a variety of conditions. *Journal of Eye Movement Research*, *2*(2), 4, 1–19.
- Pannasch, S., Schulz, J., & Velichkovsky, B. M. (2011). On the control of visual fixation durations in free viewing of complex images. *Attention, Perception, & Psychophysics*, *73*, 1120–1132.
- Peterson, M. F., & Eckstein, M. P. (2012). Looking just below the eyes is optimal across face recognition tasks. *Proceedings of the National Academy of Sciences USA*, *109*(48), 3314–3323.
- Phelps, E. A., O'Connor, K. J., Cunningham, W. A., Funayama, E. S., Gatenby, J. C., Gore, J. C., & Banaji, M. R. (2000). Performance on indirect measures of race evaluation predicts amygdala activation. *Journal of Cognitive Neuroscience*, *12*, 729–738. doi:10.1111/1467-8721.ep10836912
- Ponterotto, J. G., Burkard, A., Rieger, B. P., Grieger, I., D'Onofrio, Dubuisson, A. ... Sax, G. (1995). Development and initial validation of the quick discrimination index (QDI). *Educational and Psychological Measurement*, *55*, 1016–1031. doi:10.1177/0013164495055006011
- Posner, M. I. (1980). Orienting of attention. *The Quarterly Journal of Experimental Psychology*, *32*(1), 3–25. doi:10.1080/00335558008248231
- Richeson J. A., & Trawalter, S. (2008). The threat of appearing prejudiced and race-based attentional biases. *Psychological Science*, *19*(2), 98–102. doi:10.1111/j.1467-9280.2008.02052.x
- Schweizer, K., Moosbrugger, H., & Goldhammer, F. (2005). The structure of the relationship between attention and intelligence. *Intelligence*, *33*, 589–611. doi:10.1016/j.intell.2005.07.001
- Sekuler, A. B., Gaspar, C. M., Gold, J. M., & Bennett, P. J. (2004). Inversion leads to quantitative, not qualitative, changes in face processing. *Current Biology*, *14*, 391–396. doi:10.1016/j.cub.2004.02.028
- Sinclair, L., & Kunda, Z. (1999). Reactions to a black professional: Motivated inhibition and activation of conflicting stereotypes. *Journal of Personality and Social Psychology*, *77*, 885–904.
- Sporer, S. L. (2001). Recognizing faces of other ethnic groups: An integration of theories. *Psychology, Public Policy, and Law*, *7*, 36–97.
- Stephan, W. G., & Finlay, K. (1999). The role of empathy in improving intergroup relations. *Journal of Social Issues*, *55*, 729–743.
- Strack, F., & Deutsch, R. (2004). Reflective and impulsive determinants of social behavior. *Personality & Social Psychology Review*, *8*, 220–247. doi:10.1207/s15327957pspr0803_1
- Tatler, B. W., Gilchrist, I. D., & Rusted, J. (2003). The time course of abstract visual representation. *Perception*, *32*, 579–592. doi:10.1068/p3396
- Tatler, B. W., Hayhoe, M. M., Land, M. F., & Ballard, D. H. (2011). Eye guidance in natural vision: Reinterpreting salience. *Journal of Vision*, *11*(5), 5. doi:10.1167/11.5.5
- Trawalter, S., Todd, A. R., Baird, A. A., & Richeson, J. A. (2008). Attending to threat: Race-based patterns of selective attention. *Journal of Experimental Social Psychology*, *44*, 1322–1327. doi:10.1016/j.jesp.2008.03.006
- Utsey, S. O., & Ponterotto, J. G. (1999). Further factorial validity assessment of scores on the quick discrimination index (QDI). *Educational & Psychological Measurement*, *59*, 325–335. doi:10.1177/00131649921969875
- Valentine, T. (1991). A unified account of the effects of distinctiveness, inversion and race in face recognition. *Quarterly Journal of Experimental Psychology*, *43*, 161–204. doi:10.1080/14640749108400966

- Valentine, T., & Endo, M. (1992). Towards an exemplar model of face processing: The effects of race and distinctiveness. *Quarterly Journal of Experimental Psychology*, *44*, 671–703. doi:10.1080/14640749208401305
- Vandenberg, L., Bouwmeester, S., Bocanegra, B. R., & Zwaan, R. A. (2013). Detecting cognitive interactions through eye movement transitions. *Journal of Memory & Language*, *69*, 445–460. doi:10.1016/j.jml.2013.05.006
- Vinette, C., Gosselin, F., & Schyns, P. G. (2004). Spatio-temporal dynamics of face recognition in a flash: It's in the eyes. *Cognitive Science*, *28*, 289–301.
- Võ, M. L.-H., Zwickel, J., & Schneider, W. X. (2010). Has someone moved my plate? The immediate and persistent effects of object location changes on gaze allocation during natural scene viewing. *Attention, Perception & Psychophysics*, *72*, 1251–1255. doi:10.3758/APP.72.5.1251
- Von der Malsburg, T., & Vasishth, S. (2013). Scanpaths reveal syntactic underrepresentation and reanalysis strategies. *Language & Cognitive Processes*, *28*, 1545–1578. doi:10.1080/01690965.2012.728232
- Walker-Smith, G. J., Gale, A. G., & Findlay, J. M. (1977). Eye movement strategies involved in face perception. *Perception*, *6*, 313–326. doi:10.1068/p060313
- Webster, M. A., & Macleod, D. I. (2011). Visual adaptation and face perception. *Philosophical transactions of the Royal Society of London*, *366*, 1702–1725.
- Wu, E. X., Laeng, B., & Magnussen, S. (2012). Through the eyes of the own-race bias: Eye-tracking and pupillometry during face recognition. *Social Neuroscience*, *7*, 202–216. doi:10.1080/17470919.2011.596946