Face age and social status exert different modulatory effects on gaze following behaviour

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Abstract

The aim of the present study was to investigate whether face age and social status information associated with faces have different effects on gaze following behaviour as an index of joint attention. Participants were instructed to perform goal-directed saccades towards a peripheral stationary target, while a task-irrelevant face with averted gaze was presented. Faces of three different age groups (younger adults; middle-aged adults; and older adults) were associated with fictional résumés which could describe distracters as high or low social status people. Results showed that face age affected both saccade accuracy and latencies. Social status did not have an effect on accuracy and only affected correct saccades with higher latencies by modulating the face age effect. It is argued that the overt orienting of joint attention could be affected both by perceptual and higher order socio-cognitive factors, but at different stages of processing.

Keywords: Joint attention, Social Status, Face Age, Gaze Following, Social cognition, Automaticity.

Introduction

Understanding what a co-specific sees is necessary for social cognition. The gaze of others allows the rapid extraction of socially relevant information such as their mental and attentional states (i.e. the focus of their attention; e.g. Baron-Cohen 1995), and allows us to understand and predict their future actions (e.g. Pierno *et al*. 2006; Innocenti *et al*., 2012). Several studies have shown that perceiving averted gaze leads the observer to automatically shift his/her attention in the same direction or towards the same object that the other person is looking at (Friesen and Kingstone, 1998; Driver *et al*., 1999; Frischen, Bayliss and Tipper, 2007). For example, an uninformative cue by a centrally-presented face gazing to one-location reliably reduces reaction time to targets presented peripherally at the location consistent with the gaze (i.e. gaze cueing effect, e.g. Driver et al., 1999).

The automatic shift of attention in the direction of another person's gaze - known as joint or social attention, can be achieved both overtly, through eye movements (gaze-following behaviour), and/or covertly without eye movements. Gaze following behaviour (i.e. overt orienting of joint attention), which is considered an early and a direct index of joint attention orienting, is present early in development (Morales *et al*., 1998; Mundy and Newell, 2007) in humans and studies have shown that many species, including non-human primates, orient gaze in the direction of a co-specific's gaze and use it for interaction (for a review see Shepherd, 2010).

In adults the automatic nature of gaze following behaviour has been shown by Ricciardelli and colleagues (2002) who by using an oculomotor task reported a significant increase in the number of erroneous saccades matching the direction of the distracting gaze (gaze following errors, GFE). This was taken as evidence that perceiving a gaze shift can interfere with the execution of an oculomotor task by affecting oculomotor programming.

However, recent studies have shown that attention orienting driven by gaze is likely to be a product of both stimulus-driven and top-down attentional mechanisms (e.g. Greene *et al*., 2009). Therefore, modulatory effects on joint attention should be possible. It is more likely, in fact, that some gaze shifts are more important than others depending on face features, environment relevance or current task.

Age is known to be one of the sources of information that is rapidly extracted from faces and is an important dimension that influences how face are attended to (e.g. Slessor *et al*., 2010), encoded and retrieved from memory (Wiese *et al*., 2008). Several studies, using different kinds of face processing-task, reported that young adults show an advantage for faces within their own age group compared to elderly faces (for a review see Anastasi & Rhodes, 2012). In a recent study, Slessor and colleagues (2010) reported a greater gaze cueing effect in younger adults for own-age face distracters than for distracters with elderly faces.

Moreover, recent studies have shown that the automatic and reflexive nature of gaze-mediated attentional orienting can be modulated by a number of high-order cognitive variables, such as the task context (Ricciardelli *et al*., 2012), social identification (Cesario, 2006; Liuzza *et al*., 2011), social status (Dalmaso *et al*., 2012¸ Shepherd *et al*., 2006), emotional expression (Tipples, 2006; Bonifacci *et al*., 2006) and familiarity (Deaner *et al*., 2007). In particular, Dalmaso and colleagues (2012) showed a greater gaze cueing effect for faces associated with high-status information. Although these authors (2012) did not report differences related to face age (younger vs. older adults) on gaze mediated attention orienting, there is evidence of both differences in interference from emotional faces of different ages (Ebner and Johnson, 2010), and of face-age effects in overt orienting of attention (Ciardo *et al*., 2012).

A possibility that has not been investigated before is whether they affect overt orienting of joint attention differently when combined together. This stems from the different nature of face age and the information regarding social status associated with the face (perceptual vs. cognitive). In particular, it is reasonable to expect that their distracting/cueing effect may vary as a function of task accuracy and response speed. In other words, given that age is a perceptual feature that is extracted rapidly from the face, one may expect that it affects early stages of saccade programming and the execution of eye movements with lower latencies. By contrast, since the processing of social status information is a more complex and time-consuming higher-order cognitive process, it should play a role later on and its effect should be more evident, for example, in the execution of eye movements with higher latencies.

In the present study we tested this hypothesis by investigating in young human adults the impact of distracting face age and associated social status information on performance in a goal-directed oculomotor task.

Methods

Participants

Thirty-two right-handed undergraduates (23 female, 9 male, mean age = 22.8 years, SD = 2.0) from the University of Milano-Bicocca participated, in exchange for course credits. All had normal or corrected to normal vision and were unaware of the experiment's purpose. The study was conducted in accordance with the Declaration of Helsinki and approved by the local ethical committee.

Stimuli

Grayscale photographs (7.98 × 15.76 degrees of visual angle) of the faces of 4 younger adults (2 females and 2 males, age range: 18-23 years), 4 middle-aged adults (2 females and 2 males, age range: 34-40 years), and 4 older adults (2 females and 2 males, age range: 74-85 years), bearing a neutral expression and a straight gaze, were used. All the photos were taken from the Productive Aging Lab Face Database (Minear and Park, 2004). The gaze direction of each photo was manipulated using Adobe Photoshop, creating face pictures with gaze-averted 0.75 degrees of visual angle both to the left and to the right.

Procedure

The experiment was carried out in a sound-attenuated room, dimly illuminated. Participants sat in front of a 19-inch LCD monitor (Samsung Syncmaster 943; 1280 × 1024 pixels; 60 Hz), with their head supported by a chin rest in order to maintain a stable eye-to-screen distance of 50 cm. At the beginning of the experimental session, participants were invited to read 12 fictional résumés associated with the photographs selected as stimuli. The résumés indicated either a relatively high social status or a relatively low social status. Social status was mainly related to educational/professional information (e.g., high status: She was recently admitted to the faculty of Medicine/He is a Public Prosecutor of the Supreme Court of Palermo; low status: He did not complete Secondary school/She was dismissed as a worker for incompetence; for a similar manipulation see Dalmaso *et al*., 2012). The résumés could be considered as brief biographies (hereafter biography). Participants were randomly divided into two groups. For participants in the first group, 6 faces (a male and a female of each age range) were displayed along with biographies indicating a relatively high social status, and the remaining 6 faces to biographies indicating a relative low social status. For participants in the second group, the same faces were displayed along with biographies indicating the opposite social status to that used for the first group. The biography presentation order was randomized. After the biography presentation, the associations created by participants between social status information and faces were tested by means of a true/false questionnaire composed of 12 items (one for each biography). The items were randomly selected from one of two lists (one containing true items and the other containing false items). Item presentation order was randomized. If participants gave a wrong answer to an item, they were immediately presented again with the biography to which the item was related. At the completion of the questionnaire, the biography procedure was restarted for those participants whose accuracy was less than 90%. Biography presentation and response collection were controlled using the software package E-Prime2 (Psychology Software Tools, Inc.).

Having successfully completed the biography procedure, participants took part in an instructed saccadic eye movement task (Figure 1). Each trial started with the presentation of a black fixation circle (diameter: 0.51 degrees of visual angle) centrally presented on the between-eyes point of a stimulus face, bearing a straight gaze, on a grey background. The face was flanked by two black target circles (diameter: 0.89 degrees of visual angle), one to the left and the other to the right of the horizontally aligned fixation circle (eccentricity: 10.66 degrees of visual angle). After a delay of 1500 ms, the color of the fixation turned either green or red. 100 ms before the fixation color change, the stimulus face bearing the straight gaze was replaced by the same face with the gaze averted either to the left or to the right. This face replacement created a dynamic gaze, shifting towards the left or the right target. Participants were required to perform a fast and accurate saccade towards the left or right target, depending on the change in color of the fixation. The correspondence between color instruction and saccade direction was inverted for half of the participants. The direction of the dynamic gaze could be congruent or incongruent with the instructed direction. Since it was task irrelevant participants were explicitly instructed to ignore the distracting face. The stimulus face, the fixation and the two targets remained on the screen until a response was given. Immediately after a response was given a new trial was presented.

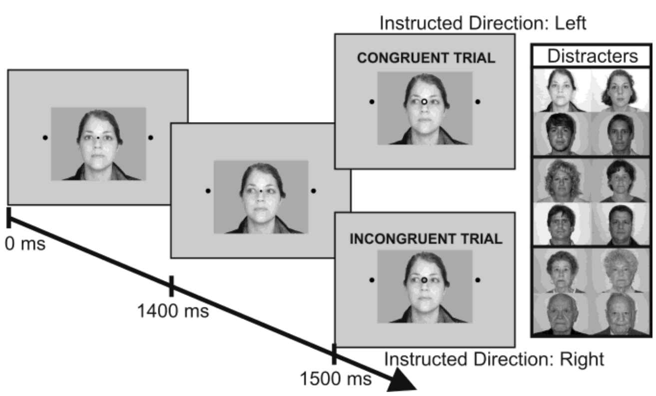

Figure 1: Experimental procedure.

Participants performed a training block, comprising 12 trials, and a test block, comprising 240 trials, with each of the 12 faces being randomly presented 20 times. In 120 test trials (10 replications of the male and the female belonging to each age range and social status), the direction of the dynamic gaze was congruent with the instructed direction. In the remaining 120 test trials (10 replications of the male and the female belonging to each age range and social status), the direction of the dynamic gaze was incongruent with the instructed direction.

The participants' eye positions and movements were recorded monocularly in real-time by an infrared video gaze tracking system (EyeLink II, SR Research Ltd., Mississauga, Ontario, Canada). For all participants, we recorded the movement of the dominant eye. Stimulus generation and presentation were controlled by the SR Research Experiment Builder software (version 1.10.56). Throughout the test block, participants took a break every 80 trials (a total of 3 breaks). During the second break, the biography procedure was repeated to maintain the association between stimulus faces and their fictional social status.

At the end of the experimental session, participants were asked to rate the age of each distracting face with a value between 1 and 99, in order to verify that they perceived the faces as belonging to the 3 age groups of interest (age manipulation check). Participants were also asked to rate the social status associated during the biography procedure to each distracting face with a value between 1 and 5 (social status manipulation check).

The experiment used a 3 × 2 × 2 repeated measures factorial design with Distracter Age (younger adults, middle-aged adults, and older adults), Distracter Social Status (high and low), and Congruency between gaze direction and instructed direction (congruent and incongruent) as the within-subjects variables.

Results

Age manipulation check

Age rating scores were entered in a one-way repeated measures ANOVA with Distracter Face (DF1, DF2, DF3, DF4, DF5, DF6, DF7, DF8, DF9, DF10, DF11, and DF12) as the within-subjects factor. The analysis revealed that the effect of Distracter Face was significant [$F(11,341) = 734.9$, $MS = 17215.9$, $p < .001$]. Post-hoc tests with Bonferroni correction showed significant differences (all $ps < .05$) among distracter faces belonging to different age manipulation levels (i.e. younger adults, middle-aged adults, and older people). Furthermore, post-hoc tests revealed that the faces belonging to each age manipulation level did not differ from each other, confirming our manipulation.

Social status manipulation check

A two-way mixed ANOVA, with Distracter Face (DF1, DF2, DF3, DF4, DF5, DF6, DF7, DF8, DF9, DF10, DF11, and DF12) as the within-subjects factor and Subject Group (Group 1 vs. Group 2) as the between-subject factor, was used to determine whether or not participants considered the distracter faces as having the same social status as in the biography procedure. The analysis revealed that the interaction between Distracter Face and Subject Group was significant [$F(11,330) = 107.97$, $MS = 68.126$, $p < .001$, Figure 2b]. Post-hoc tests, performed as before, showed significant differences between distracter faces associated with biographies emphasizing different social status levels (high vs. low). Furthermore, post-hoc tests revealed that the faces associated with biographies belonging to the same social status level did not differ from each other, confirming our manipulation.

Saccadic eye movement errors

Practice trials were discarded from the analyses. Saccadic eye movements were defined as correct if landing within ± 2 degrees of visual angle of the instructed target along the horizontal dimension. Saccadic eye movements landing within ± 2 degrees of visual angle of the non-instructed target along the horizontal dimension were defined as Gaze Following Errors (GFE) in the incongruent trials (i.e. incongruency between distracter's gaze direction and instructed direction), or as Generic Errors (GE) in the congruent trials (i.e. congruency between distracter's gaze direction and instructed direction). Saccadic eye movements landing outside ± 2 degrees of visual angle of either the instructed or not-instructed target along the horizontal dimension were defined as Saccades to Nothing Errors (SNE, 14.5 % of total trials) and were excluded from the analysis.

The first focus of interest was the difference between GFE and GE since it provides a direct and early measure of the automatic tendency to follow the distracting gaze direction. Mean percentages of GFE and GE across subjects were computed for each combination of Distracter Age and Distracter Social Status. These data were entered in a three-way repeated measures ANOVA, with Error Type (GFE and GE), Distracter Age (younger adults, middle-aged adults, and older adults), and Distracter Social Status (high and low) as within-subjects factors. Post-hoc comparisons were performed using the Duncan's test with an alpha level of .05. The analysis revealed that the main effect of Error Type was significant [$F(1,31) = 35.59$, $MS = 10385.44$, $p < .001$], indicating that participants made more GFE than GE (13.40 % vs. 2.99 %). This confirmed the automatic tendency of participants to follow the distracter's gaze (for similar results see e.g., Ricciardelli *et al.*, 2002). The analysis also showed a significant main effect of Distracter Age [$F(2,62) = 6.01$, $MS = 244.37$, $p < .005$] and a significant Error Type × Distracter Age interaction [$F(2,62) = 12.80$, $MS = 833.07$, $p < .001$], indicating that the age of the distracter critically modulated GFE but not GE. Specifically, GFE measured for middle-aged distracters (17.25%) were higher than GFE measured for both younger (13.55 %, $p < .02$) and older distracters (9.39 %, $p < .001$), which were also significantly different from each other ($p < .006$). No other main effects or interactions were significant.

Saccadic eye movement latencies

The second focus of interest was the reaction times (RTs) of correct saccadic eye movements, since they could provide an indirect measure of the interference/cueing effect of the distracting gaze. Indeed, although people may be able to suppress the automatic tendency to make saccades in the direction of the distracting gaze, one might expect a higher latency for saccades in the incongruent trials than in the congruent trials. Moreover, if the social status of the distracter exerts an effect on joint attention through a more cognitive/higher-level mechanism than that related to the age of the distracter, as we had hypothesized, then a different modulation of saccadic eye movements over time should be observed by these two factors. Specifically, the magnitude of the distracter social status effect should increase as the latency of correct saccadic eye movements increases, whereas the magnitude of the distracter age effect should decrease.

To this end, we computed median RT values of correct saccades for the first to the second bin of the individual rank-ordered raw data, separately for each combination of Distracter Age, Distracter Social Status, and Congruency between gaze direction and instructed direction. One subject was excluded from the analysis since the number of his correct saccades was not sufficient to appropriately compute median values of RTs for each combination of the experimental factors. An index of the interference effect of the distracting gaze was then obtained by subtracting the median RT values in the congruent trials from the median RT values in the incongruent trials for each of the Distracter Age and Distracter Social Status conditions, and each participant. These data were entered in a three-way repeated measures ANOVA, with Distracter Age (younger adults, middle-aged adults, and older adults), Distracter Social Status (low and high), and Bin (first and second) as within subjects-factors. Post-hoc comparisons were performed using the Duncan's test with an alpha level of .05. The ANOVA showed a main effect of Distracter Age [$F(2,60) = 8.56$, $MS = 10482$, $p < .001$], indicating a higher interference index for both the younger (30.15 ms, effect size = .56) and middle-aged distracters (23.94 ms, effect size = .44) compared to the older distracters (12.05 ms, effect size = .21, $p < .001$, $p < .01$, respectively). In addition, the analysis showed a significant two-way interaction between Distracter Age and Distracter Social Status [$F(2,60) = 4.35$, $MS = 5150$, $p < .02$], and a significant three-way interaction between Distracter Age, Distracter Social Status and Bin [$F(2,60) = 3.64$, $MS = 2441$, $p < .04$], Noticeably, as specifically suggested by the three way interaction (Figure 2), the social status of the distracter had an effect on saccadic eye movements with higher latency only. Indeed, post-hoc comparisons showed that, for trials belonging to the second bin, younger distracters with a low social status produced a higher interference index (42.76 ms, effect size = .64) than the same distracters with a high social status (24.32 ms, effect size = .34, $p < .02$). By contrast, middle-aged distracters produced a higher interference index when they were associated with a high social status (33.83 ms, effect size = .45) than a low one (9.93 ms, effect size = .13, $p < .01$). No difference between high and low social status was found for older distracters. For trials belonging to the first bin, post-hoc comparisons indicated a higher interference index for both the younger (low status = 29.10 ms, effect size = .68; high status = 24.41 ms, effect size = .59) and middle-aged distracters (low status = 23.74 ms, effect size = .52; high status = 28.26 ms, effect size = .66) compared to older distracters (low status = 9.61 ms, effect size = .21; high status = 14.88 ms, effect size = .31), independent of social status (all *p*s < .05).

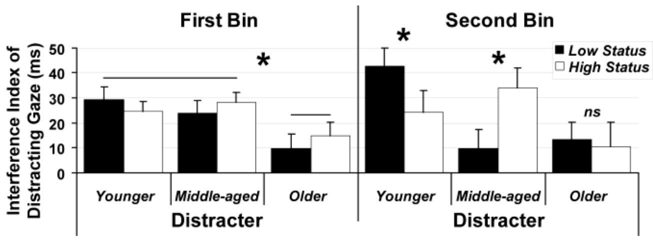

Figure 2: Mean index of the interference effect exerted by the distracting gaze (median RT values of correct saccades in the incongruent trials minus median RT values of correct saccades in the congruent trials) as a function of Distracter Age (younger, middle-aged, and older adults), separately for each Distracter Social (and Bin. Error bars represent the standard errors of means across participants.

Finally, to confirm the finding that the distracter social status modulates joint attention only at a later stage, we focused on the RTs of GFE. Since no effect of the distracter status was found on GFE percentage, one might predict that GFE latencies squarely match those of correct saccades which were placed in the first bin. To this end, we computed the number of GFE with latencies falling in the correct saccades' first bin, separately for each subject. A chi-square test revealed that GFE had latencies which fell in the first bin more frequently (85.3 %) than would be expected (χ^2 = 110.75, *df* = 30, $p < .0001$), further supporting the idea that the social status of the distracter exerts a high-level effect on gaze following behaviour.

Discussion

In this study, we investigated the impact of face age and social status information on gaze following behaviour in young adults performing an oculomotor task. This was achieved by presenting distracters of different ages whose faces were associated with a fictional biography which could describe the distracter as a high or low status person.

Our results confirmed the automatic nature of gaze following behaviour as the percentage of gaze following errors was higher than the percentage of generic errors (Ricciardelli *et al.*, 2002; 2012). Interestingly, participants made less GFE with older distracters compared to all other distracters. Older distracters also interfered less with the execution of correct saccades, suggesting that older distracting faces are easier to ignore. This result is in line with previous studies that investigated the effect of distracter's age on gaze cueing in young adults (Slessor *et al.*, 2010; Ebner *et al.* 2010), and reported less distracting effect of averted gaze for elderly faces. It has been proposed that young adults may find it easier to ignore gaze cues from elderly distracters as they are less familiar with their facial features (Deaner *et al.*, 2007). Similar differential results have been observed also for face recognition and processing (for a review see Anastasi & Rhodes, 2012).

In addition, we found that young adults made more GFE with middle-aged distracters than with younger distracters, indicating a general other-age bias on gaze following behaviour, rather than an own-age bias. The lack of an own-age bias was confirmed also by the results relative to saccadic eye movement latencies. The occurrence of a super-ordinate categorization (Gaertner & Dovidio, 2000) of younger and middle-aged distracters may provide a viable explanation of this unpredicted pattern of results. According to Gaertner and Dovidio's (2000) common in-group identity model, when people perceive others as out-group members on the basis of a certain identity cue, and, simultaneously, can form, together with these out-group members, a common super-ordinate super-ordinate group on the basis of another identity cue, the favouritism these people have for their in-group members would be redirected toward out-group members included within the super-ordinate super-ordinate group. Therefore, we can surmise that participants of our study classified younger and middle-aged distracters as in-group and out-group members, respectively, on account of face age estimation, and as members of the same super-ordinate group on account of another facial cue estimation, such as facial similarity.

The novel result of our study is that face age, but not social status information, affects GFE. Social status has an effect on saccadic eye movements with higher latency only. Previous studies investigating the role of social status on gaze-mediated covert orienting of attention (Dalmaso *et al.*, 2012) reported that high status individuals produced a stronger gaze cueing effect (Dalmaso *et al.*, 2012); by contrast, our results indicate that in young adults gaze cueing is facilitated (i.e. slower saccadic reaction times) by own-age low-status distracters. The contrast between our results and those of Dalmaso *et al.*'s (2012) study could be due to differences in the stimuli used. In Dalmaso *et al.*'s (2012) work, photos depicting only male faces were used as stimuli, while in our study we used both female and male distracters. Indeed, gender is an element from which social status could also be perceived implicitly, and it was established that male faces are perceived to be more dominant (i.e. higher social status) than female faces (Jones *et al.*, 2010). It is possible that the influences on gaze following behaviour of information about social status may also depend on how it is induced, i.e. whether explicitly or implicitly. Alternatively, own-age low status faces could represent a threat to the social identity of high-status groups (Scheepers *et al.*, 2004); as a source of threat, such low-status individuals should be monitored continually.

In conclusion, our findings extended previous joint attention studies by indicating that the overt orienting of attention driven by gaze could be differently modulated both by perceptual features and high-order socio-cognitive factors of the seen face. Taken together, our results indicate that a perceptual manipulation of an identity cue (i.e. age), exerts an effect on gaze following parameters in the early stages of saccade programming and execution. By contrast, higher-order manipulation of another identity cue (i.e. social status) affects gaze following parameters at the later stages of saccade programming and execution. This could be due either to the kind of manipulation (perceptual vs. higher-order) or to the kind of identity cue (age vs. social-status). Future studies are needed to clarify the role of different identity cues (such as age, race, gender, celebrity or political affiliation) and manipulations on the time course and patterns of gaze following parameters, in order to explore the possibility that different identity cues fit into a few broad categories or continua, such as identity valence, which have different effects on overt orienting of attention.

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