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Original Communication

The Glasses Stereotype Revisited

Effects of Eyeglasses on Perception, Recognition, and Impression of Faces

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Abstract. In face perception, besides physiognomic changes, accessories like eyeglasses can influence facial appearance. According to a stereotype, people who wear glasses are more intelligent, but less attractive. In a series of four experiments, we showed how full-rim and rimless glasses, differing with respect to the amount of face they cover, affect face perception, recognition, distinctiveness, and the attribution of stereotypes. Eyeglasses generally directed observers' gaze to the eye regions; rimless glasses made faces appear less distinctive and resulted in reduced distinctiveness in matching and in recognition tasks. Moreover, the stereotype was confirmed but depended on the kind of glasses – rimless glasses yielded an increase in perceived trustworthiness, but not a decrease in attractiveness. Thus, glasses affect how we perceive the faces of the people wearing them and, in accordance with an old stereotype, they can lower how attractive, but increase how intelligent and trustworthy people wearing them appear. These effects depend on the kind of glasses worn.

Keywords: face perception, eyeglasses, stereotypes, distinctiveness, attractiveness

"Hey, four eyes!" People who wore glasses as children probably remember hearing this insulting epithet in their schooldays. Furthermore, an unwritten law of school bullies states that you must not hit people who wear glasses. Also, after getting new glasses, your friends may tell you that your new look is quite different or that they did not recognize you right away. These experiences of people who wear glasses show us that glasses, (a) being facial attributes and fashion accessories, affect how faces are perceived and identified, and (b) influence the attribution of certain personality traits by generating stereotypes.

Faces are often assigned a special status because they reveal numerous kinds of information, such as a person's identity, facial expressions, and verbal or nonverbal facial communication, but also age and gender, distinctiveness and attractiveness (Bruce & Young, 1986). Moreover, it has been shown that special processes might be involved in "reading" facial information: It seems that faces are perceived in a holistic manner (Leder & Carbon, 2006; Tanaka & Farah, 1993) and with special emphasis on configural features (Leder & Bruce, 2000; McKone & Yovel, 2009). Moreover, specialized, though not necessarily exclusive, brain regions are involved in the processing of faces (Haxby, 2000). Because of their prominent position in the visual field, often at the observer's eye level, faces are processed in a very focal way, which allows for particularly detailed visual analyses. Even for unfamiliar faces, a large variety of classifications can be made. Gender, age, attractiveness (Zebrowitz, 1997), intelligence and health (Zebrowitz & Rhodes, 2004), and distinctiveness (Leder & Bruce, 1998) can be inferred from specialized visual processes. Moreover, stereotypes that assign traits to certain features have also been identified. For example, people with faces that have babyish features are often judged as being less mature, and more innocent, but also less responsible (Zebrowitz & Montepare, 1992). Competence, on the other hand, (of faces of politicians) is associated with greater jaw angularity and closer eyes and eyebrows (Olivola & Todorov, 2010). Faces undergo changes over time through aging (Schweinberger et al., 2010), changing health, hairstyle fashions, and facial hair (Bruce, 1988; Wright & Sladden, 2003), but also through accessories. Eyeglasses are among the most frequent accessories and are, moreover, located in the eye region. Today, besides correcting sight, glasses serve as facial accessories and often also meet fashion demands.

There has been surprisingly little research regarding the change in how people are perceived and judged when they wear glasses. The primary use of eyeglasses is their ability to correct congenital or acquired vision deficits such as myopia, presbyopia, or astigmatism. However, as only the lenses are the medical aids, there is a huge market for different kinds of frames that vary in shape and/or color. Technical innovations as well as fashion trends permanently induce changes (Carbon, 2010); the frames range from big,

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thick, peculiar rims to rimless glasses in which the frame temples are attached directly to the lenses. The resulting variation in the level of facial occlusion makes it ideal to compare full-rim with rimless glasses to study the effects of glasses on perception, recognition, and stereotypical evaluation. Thus, comparing faces not wearing glasses with faces wearing glasses with or without rims allows us to assess how the quantity of rim moderates these effects.

Regarding the perception and appearance of faces, eyeglasses are interesting because by nature they frame the eye regions and add features to those essential facial regions that have been found to receive the most fixations (Bindemann, Scheepers, & Burton, 2009; Henderson, Falk, Minut, Dyer, & Mahadevan, 2001; Henderson, Williams, & Falk, 2005; Yarbus, 1967). This prominence is already found at a very early age (Maurer, 1985) and provides information about gaze, an important ingredient in social interaction (Bayliss & Tipper, 2006). Furthermore, faces (especially the eye region) seem to elicit a distinct neuronal response, the N170, when facial stimuli are processed (Bentin, Allison, Puce, Perez, & McCarthy, 1996; Itier, Latinus, & Taylor, 2006; Kloth & Schweinberger, 2010). Also, an individual's emotional state can partly be inferred from the eye region, as the muscles of the eye region are involved in various emotional displays. So the eye region is probably the most prominent part of the face. The effect of eyeglasses on the perception of a face and the eye region in particular is not well-studied. With glasses, the eye region may become even more prominent; alternatively, glasses can also reduce the salience of this region through occlusion of some important textural features involved in its perception (Leder, 1996). Thus, in a first experiment, we explored whether different types of glasses influence observers' fixation on the eye region. In particular, full-rim glasses might attract attention and lead to longer fixations on the eye region because of their prominence. As rimless glasses are by design more minimalistic, the attracted attention and the fixation duration might be comparable to faces without glasses.

Another important aspect concerns recognition. Face recognition is largely determined by its distinctiveness (Dewhurst, Hay, & Wickham, 2005; Leder & Bruce, 1998; Valentine & Bruce, 1986a,b). As glasses add an element to the face, they may increase a face's distinctiveness. According to Valentine's model, recognition is accomplished because a perceiver selects the features that stand out and matches these with distinctive features that are essential in memory representations. The more outstanding the distinctive feature, the better a person is recognized (Unnikrishnan, 2009; Valentine, 1991), whereas typical faces are more likely to be judged as previously seen (Hancock, Bruce, & Burton, 2000). Burton, Jenkins, Hancock, and White (2005) showed that recognition of a face is enhanced when different views of a face are combined in an average. This mechanism reduces facial variability that would result from viewing conditions and related featural changes from aging, accessories, and hairstyle. If such integration of accessories to facial representations includes glasses, then full-rim glasses might especially enhance the distinctiveness of a face because of their perceptual prominence.

However, Terry (1993) found that faces wearing glasses were recognized less well, which seems to contradict the suggestion that glasses have an effect on facial distinctiveness. On the other hand, glasses might also hinder access to the eye region through their inherent artificial features and, thus, reduce access to the visual information inferred from a face. In a second experiment, we, therefore, examined whether the observers' speed of matching faces depends on the types of glasses worn by the observed faces. In a simultaneous matching task, the perceptual properties of eyeglasses should influence face perception. As full-rim glasses are an easily detectable feature, they might enhance the matching speed, especially in same-face trials. When two different faces or different versions of the same face are shown, full-rim glasses might hinder face perception since they occlude part of the face. In a sequential matching task, the retrieval of a face from memory is required. The greater distinctiveness of faces wearing full-rim glasses should again enhance the matching speed when the same face is presented with a delay. However, in different trials or when different versions of the same face are to be matched, the occlusion of some parts of the face by the frames might reduce the matching speed. Such effects might be different for rimless glasses, which presumably are more similar to faces without glasses.

In a third experiment, we tested whether long-term memory performance is affected by faces wearing glasses or adding glasses to the faces. Again, as full-rim glasses might result in higher distinctiveness, memory for faces wearing full-rim glasses might be enhanced. On the other hand, full-rim glasses occlude parts of the face and, therefore, may influence perception and subsequently recognition. Rimless glasses, however, are less prominent, so memory performance should be comparable to that for faces not wearing glasses. Referring to our introductory anecdotes, the change made by introducing glasses was another topic of these studies. We compared conditions in which the style of eyeglasses – no glasses, rimless glasses, or full-rim glasses – was maintained during a study phase and a tested recognition phase with a task in which the eyeglasses were newly introduced in the testing phase.

A lower level of distinctiveness also accompanies an often reported increase in averageness (Light, Hollander, & Kayra-Stuart, 1981; Perrett, May, & Yoshikawa, 1994). Attractiveness seems to be a marker for genetic quality: Facial attractiveness somehow signals health and that the individual grew up in a stable environment (Hume & Montgomerie, 2001). Actually, some researchers claim that averageness is a main determinant of beauty in faces (Langlois & Roggman, 1990; Rhodes, 2006). Thus, effects that change a face's distinctiveness might have an effect on its attractiveness. Therefore, full-rim glasses might reduce the perceived attractiveness of a face, while this effect should be smaller for rimless glasses. However, there are also oth-

er factors that affect facial attractiveness. Positive facial expression such as smiling and joy increase perceived attractiveness (Winston, O'Doherty, Kilner, Perrett, & Dolan, 2007). Changes in facial appearance have been the object of studies regarding the glasses stereotype. In short, this stereotype states that individuals with glasses are judged as being more intelligent, but less attractive. Some studies have addressed such evaluations and have consistently found that people who wear glasses were judged as being more intelligent (Edwards, 1987; Harris, 1991; Hellström & Tekle, 1994; Thornton, 1943) and less attractive (Hasart & Hutchinson, 1993; Lundberg & Sheehan, 1994; Terry & Kroger, 1976) than those not wearing glasses. While Harris (1991) found that this devaluation of attractiveness from wearing glasses was found for faces of both genders, Terry and Hall (1989) found that the effect of reduced attractiveness was stronger for female than for male faces. Nonetheless, these studies had some shortcomings: The few studies in which eyeglasses were addressed as affecting face appearance relied on small samples and rather unsystematic variations in conditions. Moreover, they used rather simple measures of traits, which did not allow the investigators to draw conclusions about the deeper nature of the stereotype.

With the large variety of types of eyeglasses, especially with the pervasiveness of rimless glasses over the years, the glasses stereotype may have become a more differentiated pattern of dependence on the kind of glasses; we addressed this possibility directly through comparing the appearance of faces with full-rim glasses and faces with rimless glasses. Thus, different kinds of glasses might have different effects, depending on whether the recognizability or the attractiveness evaluation is in the focus of interest. So, in a fourth study, we tested whether the glasses stereotype can be replicated and actually holds for rimless glasses. Moreover, in order to get a more differentiated view, we employed several measures of attractiveness and personality traits. Rather than testing a gross measure of intelligence, we used three scales that might represent different facets of the intelligence aspect of the stereotype. Apart from intelligence, we asked participants to evaluate successfulness and trustworthiness. Moreover, regarding the stereotype of attractiveness, apart from general attractiveness ("How attractive is this person?"), we included two social dimensions of attractiveness (McCroskey & McCain, 1974) and asked participants to evaluate the likability and cooperativeness of each person.

Experiment 1

In the first experiment, we tested how different styles of eyeglasses (no glasses, rimless glasses, full-rim glasses) affected the observers' attention to the eye region by recording gaze duration in an eye-tracking experiment.

Method

Participants

Twenty psychology students from the University of Vienna (14 female), aged 20–32 years, participated in the experiment for course credit.

Material

The stimulus pool consisted of 83 faces (41 male) of people aged between 15–58 years (M = 37.5). The distribution of gender was balanced across the age range. Each stimulus person was photographed three times from a frontal viewpoint, once without glasses, once with rimless glasses, and once with full-rim glasses (see Figure 1 for sample stimuli). All eyeglasses were chosen individually for each model by a fashion consultant. This would assure a good match between the face and the two types of glasses. To standardize the photographing procedure, the participants were instructed to show a neutral facial expression. Five face pictures had to be removed from the initial stimulus pool because of image quality issues, leaving 78 stimuli in the final pool. All images were rated in a prestudy (48 people rated the pool of 78 stimuli via an online study) with respect to distinctiveness and attractiveness. For the eye-tracking experiment, 26 moderately distinctive faces with the highest image quality were chosen. In the experiment, stimuli were presented at a size of 26 × 20 cm (10.2" × 7.9").

Figure 1. Sample stimuli from the initial stimulus pool (left: face without glasses, middle: face with full-rim glasses, right: face with rimless glasses).

Apparatus

Eye movements and gaze duration were measured with an Eyelink 1000 (SR Research Ltd., Mississauga, ON, Canada) desktop-mounted eye-tracker with a sampling rate of 1000 Hz. The pictures were presented on a 19 inch CRT monitor at a screen resolution of 1024 × 768 with a refresh rate of 120 Hz. The viewing distance was fixed at 65 cm (25.6") by using a head and chin rest. The experimental procedure and stimulus presentation were controlled using

Experiment Builder (SR Research Ltd., Mississauga, ON, Canada).

Procedure

All 26 face stimuli were shown without glasses, with full-rim glasses, and with rimless glasses, resulting in 78 trials. As the gaze pattern partially depends on the given task, we posed two different tasks. All faces were to be rated for both attractiveness and distinctiveness on a 7-point Likert scale ranging from 1 (*not at all*) to 7 (*very much*). The sequence of both the rating dimensions and the faces was randomized across participants. First, a fixation cross was presented, on which participants fixated to start the trial. Then a face was presented in the center of the screen for 5000 ms, followed by the rating scale. All faces were to be rated first on one dimension then on the other. The participants were instructed to rate the faces according to their initial spontaneous impression.

Results and Discussion

Attractiveness and Distinctiveness

We performed two separate repeated measurement ANOVAS with face version as a within-subject factor and with either the attractiveness rating or the distinctiveness rating as the dependent variable. For attractiveness, there was no significant effect of face version, $F(2, 38) = 0.45$, $p = .64$, $\eta_p^2 = .02$. For distinctiveness, there was a significant effect of face version, $F(2, 38) = 16.13$, $p < .001$, $\eta_p^2 = .46$. Faces with full-rim glasses ($M = 3.90$, $SE = 0.13$) were judged to be significantly more distinctive than faces without glasses ($M = 3.51$, $SE = 0.14$, $p < .01$, Bonferroni adjusted) or faces with rimless glasses ($M = 3.35$, $SE = 0.15$, $p < .001$, Bonferroni adjusted). The comparison between faces without glasses and faces with rimless glasses was not significant ($p = .07$, Bonferroni adjusted).

Eye-Tracking Data

To identify the allocation of attention to the eye region, we defined two regions of interest (ROI). One ROI contained the eye region of the face that incorporated the glasses when present; the other ROI contained fixations on the rest of the face. As the presentation time was limited to 5000 ms, absolute dwell time within these ROIs was analyzed. A two-way repeated measurement ANOVA analyzing fixations on the eye region with face version (no glasses, full-rim glasses, or rimless glasses) and rating type (attractiveness or distinctiveness) showed a significant main effect for face version, $F(2, 36) = 5.26$, $p < .01$, $\eta_p^2 = .23$, and a trend for rating type, $F(1, 18) = 4.36$, $p = .051$, $\eta_p^2 = .20$. Interactions between face version and rating type were not significant, $F(2, 36) = 0.88$, $p = .43$, $\eta_p^2 = .05$. Bonferroni-adjusted pairwise comparisons showed a significant difference in dwell time within the eye region between faces without glasses ($M = 3362$, $SE = 115.22$) and both faces with rimless glasses ($M = 3474$, $SE = 137.00$, $p < .05$) and faces with full-rim glasses ($M = 3505$, $SE = 149.52$, $p < .05$). For attention allocated to the head region (i.e., all fixations on the rest of the face outside the eye region), we found similar results. Face version had a significant effect on dwell time within the head region, $F(2, 36) = 8.59$, $p < .001$, $\eta_p^2 = .32$. Neither rating type (attractiveness or distinctiveness), $F(1, 18) = 0.48$, $p = .50$, $\eta_p^2 = .03$), nor the interaction between face version and rating type, $F(2, 36) = 0.23$, $p = .79$, $\eta_p^2 = .01$, was significant. Dwell time within the head region (without eye region) was significantly longer for faces without glasses ($M = 1211$, $SE = 100.03$) than for both faces with rimless glasses ($M = 1109$, $SE = 88.97$, $p < .05$) and faces with full-rim glasses ($M = 1068$, $SE = 89.55$, $p < .05$).

The analyses revealed typical gaze patterns when participants viewed faces. In accordance with previous findings, the eye region was fixated more than the other regions of the face. The two different rating tasks did not influence the gaze patterns significantly. Therefore, the prominence of the eye region seemed unaffected by the task examined here. In accordance with the hypotheses that eyeglasses add a feature to a face, and, thereby, make the eye region more salient, both types of glasses led to more fixations on the eye region. Glasses with rims increase the visual contrast of the eye region. As high contrast captures attention more readily (Itti, Koch, & Niebur, 1998), full-rim glasses resulted in more attention to the eye region. This explanation does not hold for rimless glasses as, by design, they do not have any rims. However, rimless glasses also resulted in more attention to the eye region. Therefore, this effect may be caused by other cognitive processes beyond attraction to contrast. For example, the temples could direct attention to the eye region, subtle reflections might attract attention, or even illusionary contours might accentuate the eye region. These explanations should be the topic of future studies. To summarize the findings of this study, both kinds of glasses increased fixations to the eye region. The eye region is important for social interactions (Bayliss & Tipper, 2006), as attention, intention, and other nonverbal emotional signals are inferred from the eyes (Itier & Batty, 2009).

Experiment 2

Glasses change the look of a person's face by adding features to the eye region; on the other hand, depending on their size, glasses may also conceal parts of the eye region. Specifically, glasses with big rims might conceal parts of a face in the eye region, whereas rimless glasses conceal less to nearly nothing of the face. Therefore, we tested whether glasses affect the speed of discrimination of same and dif-

ferent faces in both a simultaneous and a sequential matching task (as in Leder, 1999).

Method

Participants

Twenty psychology students from the University of Vienna (17 female), aged 19–29 years, participated in Experiment 2 for course credit.

Material

Thirty-six faces were chosen from the initial stimulus pool (see Experiment 1). To avoid recognition or discrimination via nonfacial cues such as clothing, hairstyle, or jewelry, a mask concealing the surroundings of the face was used. Furthermore, the pictures were converted to gray scale to reduce the effects of skin color or lighting differences. In order to make the task more difficult, the faces were combined as pairs based on an expert evaluation of similarity, thus, preventing distinction based on semantic categories (e.g., a very young face compared with a much older face). At least one of the two pictures in a pair was always a face without glasses. Overall 180 pairs were created, of which 108 pairs showed identical faces and 72 pairs showed different faces. The number of identical pairs arose from the combination of the 36 faces in the three conditions. For the two different-face conditions, we only chose pairs of faces that were rather similar in order to maintain a similar level of difficulty in both conditions. This resulted in 72 pairs of similar faces.

Procedure

The experiment consisted of two different tasks. In the simultaneous matching task, each trial started with a fixation cross on the left side of the screen for 1000 ms. Then the picture with the face without glasses appeared on the left and the other picture (the same or a different face with either full-rim glasses, rimless glasses, or no glasses) on the right. Participants were to decide as quickly as possible whether the two faces (not the pictures) were identical or different. The distance from the screen was fixed so that the two pictures were 32.2 ° apart. The sequence of the pairs was randomized across participants. In the sequential matching task, the two faces were presented consecutively, separated by a delay of 1500 ms. First a fixation cross was presented on the left side of the screen for 1,000 ms, then the first face appeared on the left for 1,000 ms, followed by a delay of 500 ms and another fixation cross on the right for 1000 ms. Then the second face was presented on the right. Again, participants were to decide as quickly as possible whether the two faces (not the pictures) were identical or different. The two parts of the experiment were balanced across participants so that half started with the simultaneous matching task and the other half with the sequential matching task. The experiment was presented on a Macintosh eMac with a 17 inch CRT monitor at a screen resolution of 1024 × 768 with a refresh rate of 100 Hz. Stimulus delivery and randomization were controlled using Psyscope X (Cohen, MacWhinney, Flatt, & Provost, 1993).

Results and Discussion

We analyzed mean reaction times (to correct trials) sampled over participants, separately for same (the same face in both images) and different trials and separately for simultaneous and sequential presentation. For each group, there were three different conditions depending on how the different-face versions were combined in a pair of images: no glasses left – no glasses right, no glasses left – full-rim glasses right, or no glasses left – rimless glasses right. For the analysis, we excluded reaction times more than 2.5 standard deviations from the mean. The mean reaction times, sampled over participants, are shown in Table 1.

Simultaneous Matching

A repeated measurement ANOVA using the means of the different trials (in which image pairs of two different people were presented) showed a significant main effect for face version, $F(2, 38) = 8.42$, $p < .001$, $\eta_p^2 = .31$. Pairwise comparisons revealed that the reaction time was significantly longer in the condition in which participants compared a face without glasses to a different face with full-rim

Table 1
Mean and standard error of reaction times to correct trials and ANOVA results

		No glasses – No glasses	No glasses – Full-rim glasses	No glasses – Rimless glasses	ANOVA		
		M (SE)	*M (SE)*	*M (SE)*	*F*	*p*	η_p^2
Simultaneous	Different face	1403 (92)	1522 (104)	1435 (92)	8.42	<.01	.37
	Same face	1214 (87)	1568 (119)	1554 (135)	33.68	<.01	.64
Sequential	Different face	884 (44)	893 (37)	907 (42)	0.55	.58	.03
	Same face	741 (32)	921 (53)	895 (53)	42.81	<.01	.69

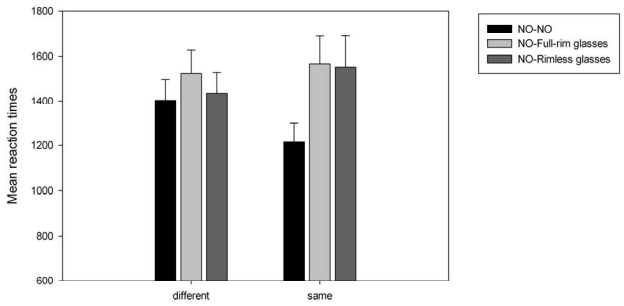

Figure 2. Mean reaction times for simultaneous matching in Experiment 2 for the three face versions (error bars = *SE*).

glasses than in the other two conditions (no glasses – no glasses, $p < .01$; no glasses – rimless glasses, $p = .02$, see Figure 2).

Analyses of the same trials revealed a significant main effect for face version, $F(2, 38) = 33.68$, $p < .001$, $\eta_p^2 = .64$. As expected, reaction times were faster for comparisons of the same faces without glasses in both pictures (i.e., the same pictures) than for the other two conditions (no glasses – full-rim glasses, $p < .001$; no glasses – rimless glasses, $p < .001$). The comparison of the conditions no glasses – full-rim glasses and no glasses – rimless glasses was not significant ($p = .63$).

Analyses concerning error rates did not reveal interesting effects. In the different-face condition, a Friedman ANOVA comparing the face versions separated by correct and incorrect comparisons showed no effect of face version in both *correct* and *incorrect* comparisons, correct: $\chi^2(2) = 3.75$, $p = .15$; incorrect: $\chi^2(2) = 2.13$, $p = .34$. In the same-face condition, there was a significant main effect of face version for both comparisons, correct: $\chi^2(2) = 13.97$, $p < .001$; incorrect: $\chi^2(2) = 14.11$, $p < .001$. Pairwise comparisons with Wilcoxon's signed rank test showed the expected results. Comparisons of the same pictures (i.e., same faces, both without glasses) were significantly more often correct and less often incorrect than the other two comparisons (all *p*s < .01).

Sequential Matching

For different trials, a repeated measurement ANOVA revealed no significant effect of face version, $F(2, 38) = 0.55$, $p = .58$, $\eta_p^2 = .03$. Trials in which the same faces were shown revealed a main effect of face version, $F(2, 38) = 42.81$, $p < .001$, $\eta_p^2 = .69$. As in the simultaneous presentation condition, reaction times were fastest in the condition in which participants compared the same pictures (i.e., same face, no glasses with no glasses) than in the other two conditions (*p*s < .001). The comparison between the conditions no glasses – full-rim glasses and no glasses – rimless glasses was not significant ($p = .10$).

Analyses of the error rates showed results similar to those in the simultaneous matching condition. For the different-face condition, there was no effect of face version for correct and incorrect responses, correct: $\chi^2(2) = 4.76$, $p = .09$; incorrect: $\chi^2(2) = 4.76$, $p = .09$. When same faces were presented, significant effects of face version were found for correct and incorrect responses, correct: $\chi^2(2) = 18.34$, $p < .001$; incorrect: $\chi^2(2) = 18.34$, $p < .001$. Pairwise comparisons revealed that matching same pictures revealed lower error rates than any other matching condition (all *p*s < .01).

The results of the simultaneous matching task showed that glasses impede the immediate recognition of faces. When two different faces were to be matched, only full-rim glasses impeded the matching. Decisions were slower when faces without glasses were to be matched with faces with full-rim glasses than for faces without glasses or rimless glasses. This supports the hypothesis that full-rim glasses impede face perception through occlusion of facial parts and, thus, hinder access to a face's identity. When faces of the same person were shown, participants were slower to match faces without glasses with those wearing either type of glasses. In contrast to the different-face condition, there was no difference between the two types of glasses. In the sequential matching task, there was no difference between the three conditions for matching different faces. For same faces, the comparison of the same picture was again much faster than the comparison of faces with and without both types of glasses, in which cases two identical images were used. Most importantly, there was no difference between the two kinds of glasses.

The difference in the results between simultaneous and sequential matching suggests that eyeglasses affect face perception by slowing access to person identity by concealing parts of the face. This may be especially true for full-rim glasses. However, in sequential matching, when faces have to be retained in short-term memory, no advantage was found for rimless glasses. The role of glasses in explicit recognition was tested even more directly in Experiment 3. Unlike in the matching paradigm employed in Experiment 2, in our everyday experience we sometimes meet people we have not seen for a while and who now wear glasses. Effects of glasses when they appear as an extra feature at testing were studied in Experiment 3.

Experiment 3

Two memory experiments were conducted: In Experiment 3a, we tested how glasses affect the recognition of faces in general and in Experiment 3b we tested whether face version (no glasses, rimless glasses, full-rim glasses) had an influence on recognition when participants only saw the faces without glasses in the learning phase.

Method of Experiment 3a

Participants

Twenty-four psychology students from the University of Vienna (18 female), aged 18–26 years, participated in Experiment 3a for course credit.

Material

To reduce the effects of distinctiveness on recognition, the 18 most distinctive faces of the 78 stimuli according to the prestudy were removed, leaving 60 faces. Half of the remaining faces formed the learning set and half formed a distracter set used during the test phase. The assignment of faces to the learning or the distracter phase was systematically balanced across participants. To avoid effects from repeated exposure to the same stimulus face, each participant saw only one version of each face during the learning phase (no glasses, rimless glasses, or full-rim glasses).

Procedure

There were three consecutive phases. In the learning phase, in which the participants saw each picture for 4000 ms and were required to rate it for distinctiveness on a 7-point Likert scale ranging from 1 (*not at all*) to 7 (*very much*). Of the 30 pictures, 10 were faces without glasses, 10 were faces with full-rim glasses, and 10 were faces with rimless glasses. Participants were not informed that recognition of the rated faces would be tested afterward. Between study phase and test phase, the participants performed a distraction task for 12 min. In this intermediary phase, they rated abstract patterns with respect to complexity. In the final test phase, the faces seen before plus 30 distracter faces (again 10 without glasses, 10 with full-rim glasses, and 10 with rimless glasses) were presented and were to be classified as *seen before* or *new*. Assignment of each face to a condition was balanced blockwise. The experiment was run using E-Prime (Psychology Software Tools, Sharpsburg, PA).

Method of Experiment 3b

Participants

Twenty-four psychology students from the University of Vienna (10 female), aged 19–42 years, participated in Experiment 3b for course credit.

Material

The pictures were identical to those used in Experiment 3a.

Procedure

The procedure was identical to Experiment 3a except that, during the learning phase, all 30 faces were presented without glasses.

Results and Discussion

Prestudy

The results of the prestudy (including the full stimulus set, see Experiment 1) showed a significant effect for face version on the rating of distinctiveness, $F(2, 94) = 6.75$, $p < .01$, $\eta_p^2 = .13$. Bonferroni-corrected pairwise comparisons revealed that full-rim glasses ($M = 3.77$, $SE = .08$) were judged to be significantly more distinctive than rimless glasses ($M = 3.47$, $SE = .08$, $p < .01$). The distinctiveness ratings of faces without glasses were in-between ($M = 3.55$, $SE = .10$).

Experiments 3a and 3b

Table 2 shows the means and standard deviations for hits, misses, false alarms, and correct rejections for each stimulus group (no glasses, full-rim glasses, and rimless glasses). Repeated measurement ANOVAs with face version as a within-subject factor and *experiment* as a between-subject factor were performed separately for hits, false alarms, misses, and correct rejections. For hits, the analysis revealed a main effect of face version, $F(2, 92) = 15.73$, $p < .01$, $\eta_p^2 = .26$, and of experiment, $F(1, 46) = 4.43$, $p < .05$, $\eta_p^2 = .09$, and a significant interaction between the two, $F(2, 92) = 15.39$, $p < .01$, $\eta_p^2 = .25$. Bonferroni-corrected pairwise comparisons revealed that, in Experiment 3b, faces without glasses were recognized more often ($M = 8.88$, $SE = .30$) than faces wearing both types of glasses (rim: $M = 7.00$, $SE = .32$, $p < .01$; rimless: $M = 6.75$, $SE = .34$, $p < .001$). For false alarms, the analysis showed a significant interaction between face version and experiment, $F(2, 88) = 3.60$, $p < .05$, $\eta_p^2 = .08$. No main effects were significant.

Table 2
Means and standard deviations in memory experiments 3a and 3b

		No glasses	Full-rim glasses	Rimless glasses
Hits	3a	8.38 (1.41)	8.04 (1.52)	8.58 (1.28)
	3b	8.88 (1.48)	7.00 (1.59)	6.75 (1.48)
Misses	3a	1.86 (1.35)	2.24 (1.41)	1.62 (1.24)
	3b	1.13 (1.48)	3.00 (1.59)	3.25 (1.98)
False alarms	3a	1.29 (1.55)	1.92 (1.41)	2.29 (1.81)
	3b	1.57 (1.25)	1.71 (1.45)	1.05 (1.02)
Correct rejections	3a	8.71 (1.55)	8.08 (1.41)	7.71 (1.81)
	3b	8.58 (1.25)	8.50 (1.47)	8.96 (1.08)

Pairwise comparisons showed that, in Experiment 3a, faces with rimless glasses were more often judged as previously seen (M = 2.30, SE = .31) than faces without glasses (M = 1.29, SE = .29, p = .02). A repeated measurement ANOVA for misses showed a main effect of face version, $F(2, 86) = 14.04$, $p < .01$, $\eta_p^2 = .25$, and a significant interaction between face version and experiment, $F(2, 86) = 13.69$, $p < .01$, $\eta_p^2 = .24$. For correct rejections, only the interaction between face version and experiment reached significance, $F(2, 92) = 3.72$, $p < .05$, $\eta_p^2 = .08$.

In accordance with the sequential matching condition in Experiment 2, the two memory experiments showed that eyeglasses do affect recognition. Recognition was highest when two identical pictures were shown at study and test. This is no surprise. However, both memory experiments indicated that recognition of faces with rimless glasses was somehow different. The first memory experiment revealed that faces with rimless glasses were more likely to be judged falsely as previously seen compared to faces without glasses. This effect may be a result of the low level of distinctiveness of faces with rimless glasses. This is supported by the results of the prestudy, which showed that faces with rimless glasses were judged to be less distinctive than faces with full-rim glasses. However, in the second memory experiment, in which eyeglasses were added to the faces in the test phase, no difference could be found between the types of glasses. This supports the previous finding that different face versions, for instance with and without glasses, may somehow become a part of the internal representation of the face (Burton et al., 2005). Experiment 4 investigated whether the comparison between the two kinds of glasses affects how persons are judged – the glasses stereotype.

Experiment 4

The purpose of the fourth experiment was to examine the effect of both full-rim glasses and rimless glasses on the evaluation of people's personality traits and attractiveness. We first expected to confirm the findings of previous studies on stereotypes about people who wear glasses (Edwards, 1987; Harris, 1991; Hasart & Hutchinson, 1993; Hellström & Tekle, 1994; Lundberg & Sheehan, 1994; Terry & Kroger, 1976; Thornton, 1943). As Experiments 1–3 showed that the version of a face (without glasses, with full-rim glasses, with rimless glasses) has an impact on perception and recognition, different glasses might also affect the glasses stereotype differently.

Moreover, we employed a design in which we explicitly tested different components of the glasses stereotype. We used three different scales, with which participants were to evaluate intelligence, successfulness, and trustworthiness, respectively. Moreover, to evaluate attractiveness, and go beyond general attractiveness ("How attractive is this person?"), we included two social dimensions of attractiveness, namely, likability and cooperativeness (McCroskey & McCain, 1974).

Method

Participants

Seventy-six participants (40 female), aged 18–65 years (M = 35.4), took part in Experiment 4. Thirty-nine participants were students of psychology from the University of Vienna and were compensated with course credit for their participation. The other participants were recruited from outside the university, comprised a wide range of occupations and ages, and received financial compensation for participating.

Material

In a prestudy, all 78 faces from our pool were rated on attractiveness and emotional expression to create three balanced pools of 26 faces each.

Procedure

To avoid effects caused by repeated exposure to the same stimulus face, each participant saw only one version of each face (no glasses, rimless glasses, or full-rim glasses). Thus, each participant saw 26 faces without glasses, 26 faces with rimless glasses, and 26 faces with full-rim glasses. All faces were rated on a 7-point Likert scale ranging from 1 (*not at all*) to 7 (*very much*) on six dimensions: successfulness, intelligence, trustworthiness, attractiveness, likability, and cooperativeness. People are very sensitive to small variations in emotionality, which is highly relevant for attractiveness (Winston, O'Doherty, Kilner, Perrett, & Dolan, 2007). Therefore, faces were also rated on a seventh dimension, emotional expression, on a 7-point Likert scale ranging from 1 (*very negative*) to 7 (*very positive*). The presentation order of the first six dimensions, presented blockwise, was randomized. In order to be able to control for the modulating effects of subtle facial expression, the facial expression scale was always presented as the last scale for each face. The whole experiment took about 45 min and was conducted on Macintosh computers with a screen resolution of 1024 × 768 with a refresh rate of 100 Hz and was controlled using Psyscope X (Cohen et al., 1993).

Results and Discussion

Rating Scales

The data were averaged across participants separately by face version and rating scale. Repeated measurements ANOVAS with face version as a within-subject factor revealed significant effects for successfulness, $F(2, 150) =$

Table 3
Scale means and standard errors sampled over participants (for emotionally neutral faces) in experiment 4

	No glasses	Full-rim glasses	Rimless glasses	ANOVA		
	M (SE)	*M (SE)*	*M (SE)*	*F*	*p*	η_p^2
Successfulness	4.16 (.08)	4.48 (.08)	4.54 (.09)	10.89	<.001	.13
Trustworthiness	4.21 (.10)	4.29 (.08)	4.45 (.10)	3.75	.03	.05
Intelligence	4.08 (.08)	4.43 (.08)	4.49 (.09)	13.40	<.001	.15
Attractiveness	3.63 (.10)	3.36 (.10)	3.44 (.10)	5.63	<.01	.07
Cooperativeness	4.18 (.10)	4.01 (.08)	4.07 (.08)	1.79	.17	.02
Likability	4.09 (.18)	3.68 (.07)	3.80 (.08)	4.00	.02	.05

26.46, $p < .001$, $\eta_p^2 = .26$; trustworthiness, $F(2, 150) = 5.91$, $p < .01$, $\eta_p^2 = .07$; intelligence, $F(2, 150) = 37.75$, $p < .001$, $\eta_p^2 = .34$; attractiveness, $F(2, 150) = 9.31$, $p < .001$, $\eta_p^2 = .11$; and emotion, $F(2, 150) = 5.98$, $p < .01$, $\eta_p^2 = .07$. The results for likability, $F(2, 150) = 1.94$, $p = .15$, $\eta_p^2 = .03$, and cooperativeness, $F(2, 150) = 2.62$, $p = .08$, $\eta_p^2 = .03$ were not significant. For the significant ANOVAs, we tested the effects through pairwise comparisons with Bonferroni adjustment. Faces without glasses were judged to be less successful and less intelligent than faces with either full-rim glasses or rimless glasses (all *p*s < .001). Furthermore, faces without glasses were judged to be less trustworthy than faces with full-rim glasses ($p < .01$). Concerning attractiveness and emotional expression, faces without glasses and faces with full-rim glasses were judged as being more attractive and emotionally more positive than faces with rimless glasses (attractiveness: $p < .001$ and $p < .05$, respectively; emotion: $p < .01$ and $p < .01$, respectively). Because the differences between kinds of glasses were rather small, this confounding prevents us from arriving at a conclusive interpretation. Therefore, in order to eliminate the confounding effects of emotional valence (i.e., positive emotional expressions lead to the attribution of more positive characteristics; Winston et al., 2007), we ran another analysis and only included faces judged as being emotionally neutral ($N = 26$). The mean values are shown in Table 3. Regarding attractiveness, this analysis revealed that faces without glasses were judged as being significantly more attractive than faces with full-rim glasses ($p < .01$). Comparisons between faces without glasses ($M = 3.63$, $SE = .10$) and faces with rimless glasses ($M = 3.44$, $SE = .10$) did not reach significance ($p = .10$). The effect of face version on perceived likability was significant, $F(2, 150) = 4.00$, $p < .05$, $\eta_p^2 = .05$, but the pairwise effect was not significant. This was a result of the conservative characteristic of the Bonferroni adjustment; without adjustment, faces without glasses were judged as being more likeable ($M = 4.09$, $SE = .18$) than faces with full-rim glasses ($M = 3.68$, $SE = .07$, $p < .05$). There was no effect on cooperativeness, $F(2, 150) = 1.79$, $p = .17$, $\eta_p^2 = .02$. Judgments of successfulness and intelligence were comparable to the analysis using all faces. Both ANOVAs showed a main effect of face version: Faces without glasses were judged as being significantly less successful or intelligent than faces with either type of glasses. As for trustworthiness, there was a change in the pairwise effects: Faces without glasses ($M = 4.21$, $SE = .10$) were judged to be less trustworthy than faces with rimless glasses ($M = 4.45$, $SE = .10$, $p < .05$).

Other Factors

Other mediating factors such as the participant's age or whether the participant wears glasses may also influence the rating of faces with or without glasses. Therefore, we incorporated these variables as covariates or additional factors in our analyses. None of these other factors were significant.

The results show that the effects of glasses on the attribution of stereotypical traits to the wearer replicate previous findings, but the comparison of different kinds of glasses revealed interesting effects. Previous findings of higher ratings of intelligence were confirmed for both types of glasses. Furthermore, persons with glasses were judged as being more successful. This may indicate a close link between success and the attribution of intelligence.

Findings for face attractiveness should be interpreted with caution because of the mediating influence of emotional expression. Analyses of emotionally neutral faces revealed that faces with full-rim glasses were judged to be less attractive than faces without glasses. Therefore, this part of the glasses stereotype seems to hold for full-rim glasses, but not for rimless glasses. The greater distinctiveness of the faces, which is related to (and may reduce) perceived attractiveness, may be the reason for the low attractiveness ratings of faces with full-rim glasses. As we saw in Experiment 3, faces with rimless glasses were judged to be significantly less distinctive than faces with full-rim glasses. Therefore, the key factor for the attractiveness of a person wearing glasses may be the prominence of the rim, as full-rim glasses lead to higher distinctiveness, which in turn leads to lower attractiveness. In summary, rimless glasses seem to have different effects on judgments concerning glasses stereotypes. What has not been shown before is that even faces with rimless glasses were judged to be more successful and more intelligent than faces without glasses. This positive stereotype had previously only been

found for faces with full-rim glasses. On the other hand, faces with rimless glasses were not judged to be less attractive than faces without glasses. Therefore, the negative stereotype that people who wear glasses are less attractive does not seem to apply to those who wear rimless glasses.

General Discussion

In four experiments, we studied how eyeglasses change the perception and impressions of faces. Glasses cover the central eye regions; this could either accentuate or disrupt perceptual access to this part of the face. Interestingly, we were able to directly compare two kinds of glasses – with and without rims – that differ in the amount of face they cover. Rimless glasses do not conceal the eye region to the extent that full-rim glasses do, so a direct comparison between the two kinds of glasses informs us about the effect of adding and concealing features in different face-processing tasks.

The first experiment employed eye movements and found that eyeglasses produce more fixations on this important face region. Therefore, in terms of gaze behavior, glasses emphasize this important face region. The importance of the eye region is revealed by many effects. Even very young infants prefer to look at the eyes as compared to any other region of the face (Maurer, 1985). Moreover, gaze is an important social dynamic and strongly influences human interaction (Langton, Law, Burton, & Schweinberger, 2008). Gaze can also affect our perception of other people, such as our impression of trustworthiness (Bayliss & Tipper, 2006). In the first experiment, both full-rim glasses and rimless glasses increased dwell time within the eye region. This cannot simply be a result of a higher saliency of the region caused by enhanced contrast around the rims. Even rimless glasses attracted longer looks to the eye region. Presumably, the reason for this effect is the additional information available in the eye region caused by any kind of glasses: Glasses may draw additional attention independent of the underlying faces. As a control study, one could superimpose something else (a tattoo, body piercing, etc.) in that region, but context would perhaps be broken.

In two matching tasks, we found that glasses slow the matching of faces. Differences were found between the two kinds of glasses in that faces with rimless glasses were matched as fast as faces with no glasses in simultaneous matching. This is in accordance with the notion that less concealment of face information in the eye region is beneficial for person recognition. In two recognition tasks, the results revealed that faces with rimless glasses, as compared to faces without glasses, were more likely to be judged falsely as having been seen previously. The explanation might be that faces with rimless glasses generally make faces appear less distinctive. This very interesting finding is supported by the findings of our prestudy, in which faces with rimless glasses were rated as being even less distinctive than faces without glasses. On the other hand, full-rim glasses increased ratings of distinctiveness. This seems to be a main difference between the two kinds of glasses tested here.

In the second memory experiment, in which glasses were only added to the faces in the test phase, no difference between the types of glasses could be found for false alarms. This supports the hypothesis that different views of a faces, for example, with and without glasses, when present in the encoding phase, may somehow become a part of the internal representation of the face (Burton et al., 2005). This explains the difference in their effect when they are part of person's representation at study and test, but also why they show different effects when they are introduced as paraphernalia at test. This has the practical implication that if someone wanted to conceal their face, or at least hinder processing of their facial identity, wearing glasses could indeed change or disrupt their facial appearance.

Finally, we addressed the glasses stereotype. We went beyond previous studies by not only asking how intelligent and attractive people with or without glasses appeared, but by also including the dimensions of successfulness, trustworthiness, likability, and cooperativeness. In short, we tested the presence of the stereotype that people wearing glasses are more intelligent (Edwards, 1987; Harris, 1991; Hellström & Tekle, 1994; Thornton, 1943) and less attractive (Hasart & Hutchinson, 1993; Lundberg & Sheehan, 1994; Terry & Kroger, 1976). We also found small differences between the two kinds of glasses, but they may have been confounded with subtle differences in facial expression. Additional analyses using those faces judged to have a neutral facial expression revealed that faces with rimless glasses, which had been found to be the least distinctive, were also judged to be more attractive and more trustworthy than faces with full-rim glasses. They, thus, showed weaker negative and slightly more positive stereotypical effects. The latter was an effect of higher perceived trustworthiness.

Including additional scales to test a more comprehensive version of the stereotype revealed interesting results. Thus, the findings of Experiment 4 suggest that this is an efficient approach for future studies regarding face stereotypes. Nonetheless, not much is known about the cause of the glasses stereotype. For example, the lower attractiveness ratings for faces with glasses may be caused by associations with health. A person's health and fitness are important factors in mating, and mating decisions might be the basis for attractiveness evaluations (Rhodes, 2006). Therefore, eyeglasses may be associated with poorer health (poorer eyesight), which causes lower attractiveness ratings. Of course, this does not explain the findings for rimless glasses and, therefore, requires more research.

When people are making judgments about the intelligence and successfulness of others, glasses may be interpreted as signs of intelligence (myopia caused by extensive reading, see Harris, 1991; Hellström & Tekle, 1994). Besides these attributions, earlier perceptual processes might also be relevant. The effect of glasses on perception and

the later attribution of traits could be the result of a two-stage process. It would, therefore, be interesting to study whether the differences in the stereotypical attribution of traits also depend on the outcome of an earlier perceptual processing stage, for example, by comparing time courses with event-related potentials. The present findings suggest at least two influences. Wearing glasses affects what is – and can be – perceived in the face and, therefore, has specific effects on perception and recognition. On the other hand, glasses may encourage drawing inferences about nonvisual, more knowledge-based information, such as a person's health and intelligence.

The present experiments also leave a few questions open. Only unfamiliar faces were studied; it would be interesting to investigate the role of eyeglasses and their integration into a person representation using familiar faces. Apart from eyeglasses, facial hair or jewelry (body piercings, earrings) might also influence not only the stereotypical evaluation of a face, but also perception and recognition. Questions concerning the issue of paraphernalia on the face warrant further research.

In the present study, we showed that wearing eyeglasses changes one's facial appearance. A practical implication of this suggests that the downside of wearing glasses, a slight decrease in attractiveness, can be allayed by wearing rimless glasses, and that wearing glasses can also result in one's appearing to be more intelligent and trustworthy.

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