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Laying Eyes on Headlights: Eye Movements Suggest Facial Features in Cars

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A B S T R A C T

Humans' proneness to see faces even in inanimate structures such as cars has long been noticed, yet empirical evidence is scarce. To examine this tendency of anthropomorphism, participants were asked to compare specific features (such as the eyes) of a face and a car front presented next to each other. Eye movement patterns indicated on which visual information participants relied to solve the task and clearly revealed the perception of facial features in cars, such as headlights as eyes or grille as nose. Most importantly, a predominance of headlights was found in attracting and guiding people's gaze irrespective of the feature they were asked to compare – equivalent to the role of the eyes during face perception. This response to abstract configurations is interpreted as an adaptive bias of the respective inherent mechanism for face perception and is evolutionarily reasonable with regard to a »better safe than sorry« strategy.

Key words: *cars, automobiles, eye movements, faces, facial features, gaze patterns, human perception*

Introduction

The human tendency of animism and anthropomorphism, i.e. interpreting even the non-living as living and in human terms, has long been noticed[1]. This propensity is revealed, for example, when we look out of the window and see faces in the clouds and is assumed to be triggered by spatial relationships of single features. But how could such a perceptual bias have evolved and persisted?

The answer is: »better safe than sorry!« That is, we gain much from being right (e.g., identifying another human, predator, prey) in vague reality and loose little when accidentally treating a non-agent as an agent, e.g. a stone as a bear[2]. Such asymmetries in the recurrent costs of errors in inference can lead to the evolution of biases even when these biases result in greater rates of inferantial error[3], and favor the persistence of a hypersensitive agent detection system[4]. But there is more to it than mere detection of presence.

Faces in particular convey much additional information such as the focus of the other's attention through head and gaze direction, sex and age, and attitudes[5] and are therefore worth our special attention. This focus of attention is reflected by fixations obtained by eye movement recording. During face perception, the duration of a fixation (i.e., periods of relative gaze stability) as well as the number of fixations that are exhibited on a specific region is highest on the eyes, nose and mouth – in descending order[6,7]. This pattern is the same for familiar and unfamiliar faces as well as upright and inverse orientated pictures[6,8]. Even in scrambled faces, people look at eyes and nose first. In summary, when exposed to faces, processing is highly determined with eyes having a special significance. Functional magnetic resonance imaging showed that face processing leads to an activation of the fusiform gyrus in the temporal lobe[9], the so-called fusiform face area. Importantly, this area is also found to be activated in laypersons[10], not just in car experts[11], when being presented with automobiles.

In other contexts, i.e. physical attractiveness, social dominance and exclusion, Maner and colleagues already demonstrated the measure of visual attention in

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general[12], and eye tracking in particular[13], to be a valid tool in the reconstruction of (evolved) perceptual biases. In the current study, we developed a specific task to explore whether people actually perceive facial features in artifacts, more specifically in cars: A face and a car front were presented next to each other and participants were asked whether these two »have the same eyes« (or, nose, mouth, or ears in other trials). By monitoring the eye movements, it can be determined on which visual information a participant relies on to solve the task. Only if the car's constituent parts do have an underlying facial signal quality, there will be an increased number of fixations on a specific region of the car front when the subject is asked to compare, e.g., the eyes, of the face and the car.

Materials and Methods

Participants

Twenty-five male and twenty-five female participants were recruited via advertisement in Austria. Their age ranged from 19 to 36 years (M=24.5, SD=3.6). They received 10 € compensation and were not allowed to have participated in previous studies using the same stimulus material. One woman had to be excluded from the analyses due to technical problems during eye movement recording.

Procedure

To realize the comparison of four different features, stimulus material was grouped in four blocks. Each block was introduced with the question (translated from German): »Do the face and the car front have the same [eyes | nose | mouth | ears]?« whereby in each block participants were asked to compare a specific feature. The participants were further instructed to develop a general impression and not to answer each question individually. Participants were allowed to take a break between the four blocks for as long as they wished. To ensure that the initial fixation position was not on the experimental stimuli, each trial started with the presentation of a fixation cross in the upper left corner of the screen for 1,000 ms. Subsequently, the stimuli were presented for 4,000 ms. This duration is commonly used in visual search paradigms including faces [e.g.12,14]. Quality of eye tracking calibration was verified prior to every trial. Ten pseudo-random sequences of the stimulus material were realized by varying the sequence of the blocks (i.e., the specific features asked to compare) as well as the order of stimuli within the blocks. The pairing of the faces and car fronts was held constant for all sequences, i.e., a specific face was always paired with the same car.

Stimuli

Each experimental stimulus was made up of two different objects: A human face with a neutral expression and a front picture of a car. Human faces were standardized frontal pictures of 19 men and 19 women of various ages. Participants were instructed to directly face the camera, which was positioned at eye height, and to approximate the Frankfort Horizontal (meaning ears and bottoms of eye sockets at the same level as described by Farkas[15]). None of the participants wore glasses, jewellery, tattoos or make up. Constant studio lighting, a 200 mm lens on a digital camera and a distance of 3 m were used to minimize optical distortions. Seventy-two pre-defined somatometric landmarks (adapted from Farkas[16]) were then marked on each facial photograph for the standardization of position, orientation and size of the facial stimuli. This iterative standardization process based on a least squares criterion was conducted in the computer program »Facial Explorer«[17] (see Rikowski and Grammer[18] for a detailed description of the procedure). Pictures were also standardized with regard to white balance, contrast and brightness, and finally superimposed by a blurred white ellipse (in Photoshop CS) to disguise contextual information such as hair style and clothing as well as to avoid any visual edges during presentation. The resulting pictures were of 380×532 pixels.

The car fronts were high resolution 3D computer models (Digital MockUps) of 38 existing car models from 2004 to 2006, comprising 26 brands, and were edited with 3ds Max (Autodesk Media & Entertainment, San Rafael, USA). All cars were colored silver and scaled to their original size. Materials such as chrome, gum, and glass as well as shadows were taken into account to give the cars a realistic appearance. License plates were erased and standardized lightening was realized by a virtual sun at a 45° angle right in front of the car. A virtual camera with a 200 mm lens was positioned in the midline at 12 m distance and at half of the height of the respective car. The frontal images of the cars were of 640×497 pixels. To realize the experimental stimuli, a face and a car front were randomly assigned and placed next to each other with the car on the right side.

Apparatus

Eye movements were recorded from the left eye using a video based IView X Hi-Speed tracking column (SensoMotoric Instruments, Germany) with a sampling rate of 250 Hz. Participants were seated in a distance of ~50 cm to a 19" CRT monitor connected to an IBM compatible desktop computer. Stimulus presentation was controlled by Presentation (Neurobehavioral Systems, CA, USA).

Analysis of eye movements and gaze direction

Between rapid eye movements with high velocities above 500° per second (so called saccades), our eyes remain relatively still (i.e., a fixation). During these fixations, our visual system takes up new information[19]. The amount of information extracted from an area of interest is reflected by the number of fixations exhibited on this specific area of interest[20]. In the current study, we calculated the center of gravity for the headlights, the grille, the additional air intake and the side-view mirrors based on the two-dimensional Cartesian coordinates of their landmarks as defined by Windhager and colleagues[21] for each car. The average of all x-coordinates of a feature's landmarks equals the x-coordinate of its center of gravity, and likewise with the y-coordinates. For the faces themselves, the center points of the pupils, »pronasale«, »stomion« and »tragion« were used as analogous centers[16].

Then each fixation was assigned to the feature with the next closest center. There was one value per paired feature, i.e. the numbers of fixations for left and right headlights and side-view mirrors, and eyes and ears respectively, were summed up. The analyses were of average numbers of fixations per feature from either car or face.

Statistics

Repeated measurement ANOVAs were conducted in SPSS 11 for each task to compare the numbers of fixations on different regions. If the criterion of statistical significance ($p \leq 0.05$) was met, pair-wise t-tests together with Bonferroni adjustments were applied as post-hoc tests. All tests were two-tailed and Cohen's d was given as effect size measure.

Results

Visualization

For the visualization of fixation patterns, heatplots were generated on the basis of the spatially smoothed total fixation time of every individual pixel and were superimposed on the stimulus material – thus reflecting the degree of attention received by the single parts: The brighter the color, the higher the total fixation time on this region. In the example depicted in Figure 1, the heatplot indicates that when subjects were asked whether the face and the car front had the same eyes, the focus of attention was on the eyes of the face and the headlights of the car.

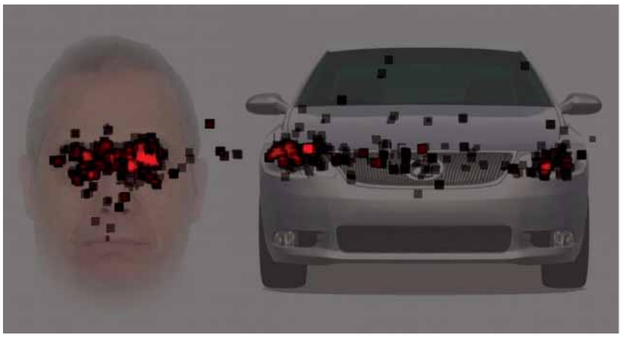

Fig. 1. Heatplot visualizing spatially smoothed total fixation times in response to the question »Do the face and the car front have the same eyes?«.

Statistical analysis

Separately for the four different tasks (i.e., the comparison of eyes, nose, mouth, or ears) the numbers of fixations exhibited on a feature were submitted to a 2×4 repeated measurement ANOVA with object-type (face *vs.* car) and fixated feature (eyes [headlights], nose [grille], mouth [additional air intake], and ears [side-view mirrors]) as within-subject factors.

To categorize fixations as belonging to a certain feature, centers of gravity of the single features were identified individually for each stimulus. In a second step, for each individual fixation, the spatial distances of the fixation to the centers of gravity were determined separately for each participant and stimulus. Subsequently, each fixation was categorized as belonging to the feature with the shortest corresponding distance; the resulting means and standard errors of the means are given in Table 1 and plotted in Figure 2.

Analysis revealed that the main effect of object-type was not significant for the comparison of eyes and the comparison of the nose, $Fs<1$, but for the comparison of

TABLE 1
MEAN NUMBERS OF FIXATIONS (UPPER ROW) AND STANDARD ERRORS OF THE MEANS (SEM, LOWER ROW) FOR THE VARIOUS REGIONS OF THE CAR FRONT AND THE HUMAN FACE SPLITTED BY TASK

	Do the face and the car front have the same …							
	… eyes?		… nose?		… mouth?		… ears?	
	Cars	Faces	Cars	Faces	Cars	Faces	Cars	Faces
Headlights/eyes	**4.02**	**4.67**	2.64	3.07*	2.78*	2.77*	3.01	3.43
SEM	0.12	0.13	0.10	0.11	0.09	0.10	0.12	0.13
Grille/nose	1.86*	1.27*	**2.92**	**2.20**	2.34	1.44*	1.56*	1.28*
SEM	0.08	0.06	0.09	0.09	0.10	0.06	0.08	0.05
Air intake/mouth	0.56*	0.88*	1.04*	1.07*	**2.05**	**2.08**	0.46*	0.91*
SEM	0.09	0.07	0.08	0.07	0.11	0.09	0.08	0.07
Side-view mirrors/ears	1.51*	1.32*	1.32*	1.28*	1.24*	1.24*	**3.38**	**3.35**
SEM	0.11	0.06	0.11	0.09	0.12	0.07	0.11	0.11

Significant mean differences between targeted feature (in bold face) and other regions on the car or face respectively are marked with an asterisk ($n=49$ subjects). The corresponding effect sizes are given in Table 2 the mouth, F(1.48)=14.99; p<0.001, and ears, F(1.48)= 4.87; p=0.03. The main effect of feature and the object-type by feature interaction were significant for all four tasks, all Fs>5.68, all ps<0.001. The individual statistics for all four tasks are provided in the Appendix.

Of theoretical relevance in the present analysis is, whether the eye movement patterns exhibited on faces and cars correspond, more specifically, whether: (A) similarities in the overall pattern of eye movements in faces and cars can be observed, and (B), whether the specific feature that had to be compared in the different tasks (e.g., the nose) resulted in a higher number of fixations on a specific feature in the car – thereby establishing a link between facial features and the corresponding features in cars. For that reason, separately for object-type and task, pair-wise comparisons between the respective target-feature of the task (e.g., the eyes) and the remaining three features (e.g., the nose, mouth, and ears) were performed by means of paired-samples t-tests. To prevent the accumulation of α-errors and preserve the overall significance level of 0.05, a medium-conservative Bonferroni α-adjustment was applied by dividing the overall significance level by the number of individual tests. The corresponding effect sizes (Cohen's d) are reported in Table 2.

An inspection of Table 1 and 2 reveals two major findings. First of all, the eyes and the headlights always – no matter what feature was asked to compare – received as many or even more fixations than the target-feature that actually had to be compared. As can be seen in the first row of Table 2, effect sizes for the comparison of the eyes/headlights with the other features were not significant or even negative. The number of fixations even increased by further 36% for the eyes and 33% for the headlights when the participants were explicitly asked to »compare the eyes«; as obvious in Figure 2, eyes and headlights outweighed the other features by far (factor 3.5 for the eyes and factor 2 for the headlights as compared to other features of the respective object). A second finding of theoretical relevance is revealed by the second, third, and fourth row of Table 1. If asked to compare the eyes, nose, or ears, the resulting eye movement patterns for faces and cars were highly similar: The target-feature was always looked at more often than the remaining features, leaving eyes and headlights aside in the latter two tasks. If asked to compare the nose, the mean number of fixations was more than twice as high for the grille as for the other features, i.e., the air intake and the side-view mirrors (see Figure 2). Similarly, numbers of fixations were more than doubled for the side-view mirrors and the ears when participants had to »compare the ears«. Interestingly, when asked to »compare the mouth«, our subjects – as apparent in Figure 2 – predominantly fixated on the mouth of the face, however, during the examination of the car, the grille and the air intake competed for the role as »mouth«.

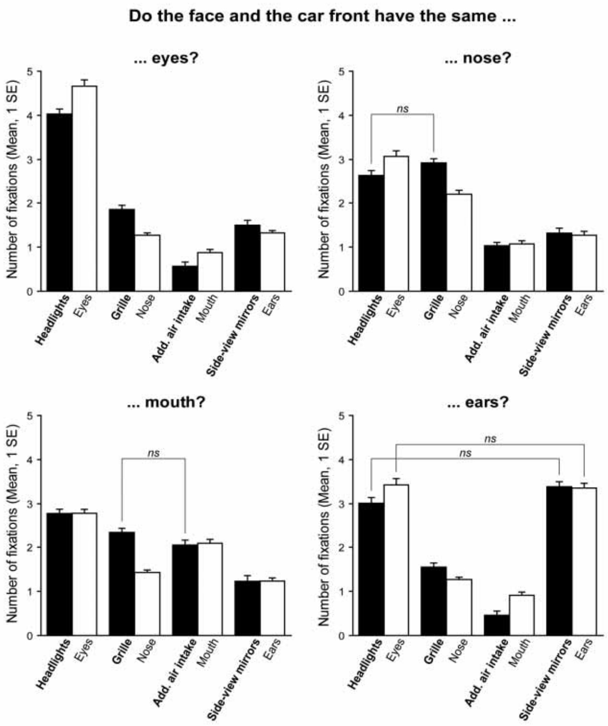

Fig. 2. Number of fixations exhibited on car fronts and faces, plotted separately for tasks and features. Pair-wise comparisons (as described in the Results) are statistically significant unless indicated otherwise (ns).

TABLE 2
EFFECT SIZES (COHEN'S D) FOR PAIR-WISE COMPARISONS BETWEEN NUMBERS OF FIXATIONS ON THE TARGETED FEATURE AND ON OTHER FEATURES OF THE CAR OR FACE, RESPECTIVELY

	Do the face and the car front have the same …							
	… eyes?		… nose?		… mouth?		… ears?	
	Cars	Faces	Cars	Faces	Cars	Faces	Cars	Faces
Headlights/eyes	0	0	0.42	–1.21*	–1.02*	–1.00*	0.45	–0.10
Grille/nose	2.94*	4.85*	0	0	–0.38	1.21*	2.66*	3.50*
Air intake/mouth	4.58*	5.24*	3.09*	2.04*	0	0	4.15*	3.71*
Side-view mirrors/ears	3.03*	4.70*	2.25*	1.52*	0.97*	1.50*	0	0

Significant comparisons are marked (*)

Discussion

In the present study, we could show that analogies of faces are actually perceived in non-living objects, namely cars. People consistently directed their gaze from the facial feature to a specific region of the car front when asked to compare eyes, nose, mouth, and ears between a face and a car. Gaze patterns revealed headlights to be considered as eyes, the grille as the nose, either the grille or the additional air intake as the mouth as well as the side-view mirrors as ears.

Yet, the most striking finding of the present study is that the number of fixations was found to be greatest on the headlights in every single condition (and further increased, when people were asked whether the face and the car front had the same eyes). So people predominately fixated the eyes and also the headlights, although they were asked to look for something else. The significance of eyes in face perception is consistent with the existing literature. Although the eye region covers just 21% of the face, it receives a (disproportionately) large percentage of gaze fixation, i.e. attention[22]. Two reasons are discussed in the current literature: On the proximate level, it is the special physical properties of the human eye such as the extraordinary high contrast between white sclera and black pupils[23], the horizontal elongation and the symmetric positioning that foster detection and can operate as indicator of the current alignment of a face[24]; and on the ultimate level, the co-evolution of physical property and social signal[23] in face detection and attention orientation up to facial expressions[25]. Such gaze-signal enhancement might have been crucial for increased cooperative and mutualistic behaviors (e.g. group hunting, scavenging) in human evolution[23]. The finding that the same attention bias exists for the headlights of a car strengthens the claim for a facial appearance of cars and the existence of an overperception error. Besides, this analogy between eyes and headlights also indicates the task independent automaticity of an evolved perceptual bias.

Thus, humans like many species are highly sensitive to such patterns no matter how abstract they are[26,27], cf. also the eyespots on many butterfly species[28]. In a recent paper[21], we could even show – using a combination of a rating study with geometric morphometrics – that human characteristics such as maturity, sex and interpersonal attitudes can be reliably inferred from car fronts and that the corresponding shapes mirror proportion shifts and feature changes known from human faces. Additional neurophysiological studies will be necessary to further investigate the similarities of face and car perception as anticipated by Erk and colleagues[10]. Another promising direction for future research will be the systematic alteration of the car stimuli in the way faces, were tested in the past (inverted, whole-part, thatcherized)[e.g.24,29,30].

In summary, we conclude that people can interpret car fronts not only as face-like, but furthermore that the automatic information seeking behavior during the perception of car fronts is based on anthropomorphic assumptions of the beholder – as reflected by eye movements. This favors the claim that animism and anthropomorphism are part of our every-day life[2,31]. Such a likewise perceptual as cognitive bias might have evolved through the ongoing selective pressure to detect every agent close-by and might not only affect design decisions nowadays.

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OČI NA PREDNJIM SVJETLIMA AUTOMOBILA: POKRETI OČIJU UKAZUJU NA FACIJALNA OBILJEŽJA KOD AUTOMOBILA

S A Ž E T A K

Ljudska sklonost da vidimo lica čak i na neživim strukturama poput automobila već je davno zamijećena, no empirijskih dokaza je malo. Kako bismo ispitali ovu tendenciju ka antropomorfizmu, ispitanicima je dano da usporede specifična obilježja lica (poput očiju) i prednji dio automobila, postavljeni jedan do drugoga. Obrasci pokreta očiju su pokazali na koje vizualne informacije se ispitanici oslanjaju pri rješavanju zadatka i ukazali na percepciju facijalnih obilježja kod automobila – naprimjer prednjih svjetala kao očiju i rešetke kao nosa. Što je najvažnije, utvrđena je dominantnost prednjih svjetala, s obzirom da su ona privlačila pogled neovisno o obilježjima koja su trebali usporediti – jednako kao što je slučaj i s očima kod percepcije lica. Ovakva reakcija na apstraktne konfiguracije je interpretirana kao adaptivno svojstvo inherentnog mehaniza za percepciju lica i evolucijski je važno kao dio strategije »sigurno je sigurno«.

Appendix

DETAILED TEST STATISTICS OF THE REPEATED MEASUREMENTS ANOVAS (49 SUBJECTS) FOR THE TASK-SPECIFIC ANALYSES WITH OBJECT-TYPE AND FEATURE AS WITHIN-SUBJECT FACTORS

Factor (df,df)	Do the face and the car front have the same …							
	… eyes?		… nose?		… mouth?		… ears?	
	F	p	F	p	F	p	F	p
Object-type (1,48)	0.37	0.38	0.99	0.33	14.99	<0.001	4.87	0.03
Feature (3,144)	514.25	<0.001	197.85	<0.001	5.68	<0.001	303.24	<0.001
Object-type by feature (3,144)	21.33	<0.001	18.68	<0.001	7.15	<0.001	7.86	<0.001