Early lifetime experience of urban living predicts social attention in real world crowds

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A B S T R A C T

More than half of the world's population is currently living in cities, with more and more people moving to densely populated areas. The experience of growing up and living in crowded environments might influence the way we explore our social environment, mainly how we attend to others. Yet, we know little about how urbanicity affects this vital function of our social life. In two studies, we use mobile eye-tracking to measure participants' social attention, while walking through a shopping mall. Results show that social density of participants' native place impacts how frequently they look at passing strangers. People who experienced more city living from birth to early adolescence, attend more to strangers' faces than their rural counterparts. Our findings demonstrate that the early experience of urban upbringing configures social attention in adulthood. The urbanicity-related bias towards social gazing might reflect a more efficient processing of social information in urban natives.

1. Introduction

Imagine being in the middle of a crowd in a metropolitan shopping mall. Hundreds of people, which enter your visual field, surround you. This typical urban experience might affect the way you explore the scene in front of your eyes, and the way you perceive the immediate social environment you are navigating through. At least you would deviate from the way you look at social encounters, as you would do it when holding a meeting with up to five colleagues at work, simply because of the amount of social information you are now facing. When exposed intensively and repeatedly to such an environment, it may require us to adapt our social gaze behavior. More specifically, being exposed to such a socially enriched environment throughout one's life is likely to adapt the mode of processing social information (Lederbogen et al., 2011). The trend towards urbanization and growing cities, which has been going on for decades and proceeds in all societies around the world, gives prominence to the question of which social-cognitive adaptations are developing as a consequence. In fact, by 2050, two out of three people are projected to live in cities. Thus, urban living marks a rapidly advancing trend, which is growing to cover a majority of the world's population. The experience of living crowded into spaces with huge numbers of people may shape the way we process social information in everyday life (Lederbogen et al., 2011). In particular, a cornerstone of social cognition, namely the way we pay attention to social information in our environment (Emery, 2000). The presence of others attracts our attention (Thompson, Foulsham, Leekam, & Jones, 2019) and shapes how we visually explore our environment (Van Praag, Kempermann, & Gage, 2000). Unlike age, gender and other socio-demographics, little attention has been paid to the influence of urban living and upbringing on social cognition. This despite initial evidence that city dwellers cope with social situations differently compared to their rural counterparts (Balasz & Saville, 2015; Lederbogen et al., 2011). We aim to bridge this gap by investigating how gaze behavior in crowded areas is shaped by early upbringing in rural and urban areas. We applied mobile eye-tracking to measure people's social attention in a natural crowd and further assessed their early living environment. Our work finds its value in delineating how naturalistic and unobstructed social gazing is impacted by the early lifetime experience of urban living. We show that growing up in cities distinctly predicts the gaze frequency towards others' faces, but not their bodies. Therefore, our findings strongly suggest that the lifetime experience of urban living fosters increased gaze signaling.

More than half of the world's population is currently living in cities, with more and more people moving from the countryside to densely

populated areas. Although people living in cities have better access to some amenities like health care, urban living has also been linked to a greater social imbalance, and a social environment, which is both more strenuous and troublesome (Abbott, 2012; Dye, 2008). Indeed, city living, and urban upbringing shape the way we deal with social stress (Lambert, Nelson, Jovanovic, & Cerdá, 2015; Lederbogen et al., 2011; Steinheuser, Ackermann, Schönfeld, & Schwabe, 2014), leads to less personal happiness (Berry & Okulicz-Kozaryn, 2011) and less networking inside the community (Sørensen, 2016). Beyond that, city life also has an impact on our brain. Changes in gray matter volume of cortical regions related to stress processing and risk for severe psychiatric illness were found to be associated with early life urbanicity (Haddad et al., 2015; Lederbogen, Haddad, & Meyer-Lindenberg, 2013). It is therefore not surprising that city dwellers are exposed to an increased risk for mental disorders (Peen, Schoevers, Beekman, & Dekker, 2010). The most consistent finding is the prevalence of schizophrenia being nearly doubled for people, who grew up in cities when compared to people, who grew up in rural areas (Krabbendam & Van Os, 2005). To conclude, research provides substantial evidence that psychological functioning might be adversely affected by urban living (Lederbogen et al., 2013). This gives rise to the assumption that the unique characteristic of cities, the living among a tremendous amount of people, could adversely affect psychological development. As the urban condition of social living exerts a sustainable impact, it is not surprising that most of the consequences of city living are social by nature. Even mental disorders associated with urbanicity are above all characterized by a severe breakdown of social cognition (Lewis et al., 2020).

However, it is worth noticing that urban upbringing impacts social cognition not only in a harmful way. One intriguing finding relates directly to the heart of social cognition: the way we recognize faces. People, who grew up in bigger cities process faces of others in a different way than those raised in rural areas (Balasz & Saville, 2015). More specifically, those of us, who have early lifetime experience of city living, develop a better ability to remember and recognize unfamiliar faces than those grown up in smaller villages. These data suggests that city living and upbringing experience shape social cognition. Yet, we do not know much about what building blocks of our social cognitive architecture are minted this way. For example, put yourself back into the situation of being in the crowded metropolitan shopping mall, where hundreds of people come into your visual field. The reflex to capture all the social information would fail, simply because you are confronted with too many people. How do you navigate your attention through this situation? Across the levels of social cognition, the way we pay attention to others is mainly affected by this social diversity of stimuli. Looking at others in social encounters is probably the most basic nonverbal signal of human communication, but above all our number one channel for gathering information about our social environment (Risko, Richardson, & Kingstone, 2016). This function is so fundamentally important that we reflexively orient towards others' faces when they appear in our visual field (Kingstone, Kachkovski, Vasilyev, Kuk, & Welsh, 2019; Langton & Bruce, 1999; Risko et al., 2016).

However, what is this reflexivity needed for? The vital function of gaze is to decode our social environment and encounters. In other words, it serves us to read others' mind states reliably. Interestingly, only the eye region is necessary to draw conclusions about others' state of mind (Baron-Cohen, 1997; Emery, 2000; Kobayashi & Hashiya, 2011). Its indispensable function to successful human interaction becomes clear in the face of its absence: disruptions of the natural flow of eye-directed gaze, present for example in severe mental disorders, mostly lead to the inability to interact adequately with the social environment. Indeed, disruptions in normal patterns of social gazing are associated with severe impairments in social functioning e.g., autism (Freeth & Bugembe, 2018) or schizophrenia (Lederbogen et al., 2013). To conclude, social gaze behavior is a cornerstone of social cognition (Emery, 2000), and thus constitutes an indispensable component of successful social interactions in our daily lives (Grossmann, 2017). Yet, this function might

be shaped in different ways, depending on whether one grew up in a metropolitan area or a small village. It is indeed well known that sociodemographics and social forces shape social gaze patterns (de Lillo et al., 2021; Maran et al., 2020). Gaze behavior follows clear rules that guide how we show attention towards others e.g., in each conversation a speaker passes the speaker role to the listener simply by directing their gaze towards the listener, which then starts to speak with averted gaze (Ho, Foulsham, & Kingstone, 2015). Similarly, when conversing while eating, each bite leads to gaze aversion from the counterpart (Wu, Bischof, & Kingstone, 2013, 2014). Interestingly, the number of people present also moderates these fundamental dynamics of social attention (Maran et al., 2020; Redcay & Schilbach, 2019; Schilbach, 2010; Schilbach et al., 2013). Therefore, in the presence of others, a socialized pilot system directing our gaze behavior begins to operate, which strongly shapes the way we pay attention towards others in our immediate social environment (e.g., Hirschauer, 2015; Zuckerman, Miserandino, & Bernieri, 1983). Urban upbringing might channel its own pilot system to direct our gaze behavior in urban social life. Put simply, the mere exposure to crowds when growing up in an urban environment might influence the visual exploration of a social scene in front of one's eyes. This suggestion of exposure effects on social cognition plausibly parallels with findings in other domains of cognitive development: environments, which provide a rich stimulation in terms of lively public places and thus social encounters, affect cognition e.g., memory function (Birch & Kelly, 2019), and behavior in terms of increased exploration activity (Van Praag et al., 2000). Think of urban areas as socially enriched environments for upbringing (Kühn et al., 2017), which when being exposed to it in early development, stimulates increased exploration of social information as provided by visual scenes. More specifically, the mere exposure to social crowds might shape ones' visual system to scanning social encounters efficiently in order to successfully navigate through the crowd. In other words, a developmental exposure to a rich social environment might affect one's way to look at others. The daily exposure to masses of people, mainly strangers, in a city might lead to different gaze behavior than the encountering of few familiar people during your daily life in a small village. Indeed, recent evidence suggests that individuals, who are repeatedly confronted with faces, e.g. face artists, develop a better and faster processing of faces (Hsiao, An, Zheng, & Chan, 2021).

Therefore, we hypothesized that individuals grown up in urban areas shift their attention to stranger faces more often than those grown up in rural areas do. More specifically, we expect hometown population density to predict the number of gaze points towards other faces in social crowds. We aimed to test this hypothesis in a real-world environment. Investigating social gaze behavior in a real-world setting is crucial, as naturalistic attention operates remarkably different in real-world environments from when faced with isolated pictures of social scenes on a computer screen in the lab (Lappi, 2016; Risko et al., 2016). For example, people look less to others, when subjects think or recognize they are being viewed by others than when looking at a social scene in the lab (Gobel, Kim, & Richardson, 2015; Laidlaw, Foulsham, Kuhn, & Kingstone, 2011; Risko & Kingstone, 2011). Most of the laboratory eye-tracking research thus fails to capture the naturalistic dynamics of social gaze behavior (Risko et al., 2016). In order to avoid this shortcoming of existing approaches, we thus exposed participants to a real-world crowd.

Put more precisely, in two field studies we used mobile eye-tracking to investigate whether urban upbringing impacts gaze behavior towards strangers in naturalistic, spontaneous social encounters. In both two field studies, participants were instructed to walk a predefined route through a crowded shopping mall. Their eye-movements were continuously tracked by a mobile eye-tracker to capture their gaze behavior towards strangers in naturalistic, spontaneous encounters within a social crowd.

2. Material and methods

2.1. Participants

The sample of study 1 consisted of 66 healthy adults (35 female, 31 male; their age ranged from 19 to 38 ($M = 22.88$, $SD = 2.75$)), which participated voluntarily in the study. The sample of our replication study (study 2) consisted of another 52 healthy young adults (31 female, 21 male). Their age ranged from 17 to 47 ($M = 24.54$, $SD = 6.08$). Both studies were conducted in line with the guidelines of the Ethics Committee of the University of - and informed consent was provided. All participants had normal or corrected-to-normal vision, and no diagnoses of neurological or mental disorders.

The applied study design and statistical analyses in both studies were exploratory. Therefore, we tried to achieve a large sample size in study 1, which was our pilot study. Sensitivity power analysis with G*Power (Faul, Erdfelder, Buchner, & Lang, 2009) showed that a sample size $N = 38$ would be sufficient to detect a medium-sized effect $f^2 = 0.37$ with a statistical power of $1 - \beta = 0.95$ and $\alpha = 0.05$ in the computed linear multiple regression models. We calculated this by applying the explained variance of $R^2 = 0.27$ from the regression models in study 1.

2.2. Procedure

We instructed our participants to walk through a crowded shopping mall along a predefined walking route for about 5–7 min. This task adapted a real-world navigation task used in previous research (e.g., de Lillo et al., 2021; Foulsham, Walker, & Kingstone, 2011). Before participants started their walk, we put on the eye-tracking glasses (Tobii Pro Glasses 2; sampling rate 100 Hz) and performed a short calibration procedure. Participants were asked to walk from the basement of a shopping mall all the way up to the third floor and back down to the starting point (see Fig. 1). We gave them detailed instructions to ensure that everyone walked the same route. As gaze behavior, especially the attention towards the eyes is partially reflexive and partially volitional (Laidlaw, Risko, & Kingstone, 2012), we did not give any instructions to our subjects concerning where they should look. Therefore, social gaze behavior of participants more likely reflected their reflexive exploration of their visual field rather than directed attention towards social stimuli (Thompson et al., 2019). After finishing their walk through the shopping mall, participants completed a questionnaire about their demographics including hometown specifics and other control variables.

Fig. 1. Example of the setup during the environment navigation task. Subjects were equipped with Tobii Pro Glasses 2 (wearable battery and memory module connected via cable) and instructed to walk through a crowded shopping mall.

2.3. Urban upbringing

In study 1, participants provided the name of the place they lived for most of the time up to age 15. Population density was then quantified as follows: population scores were divided by surface area (e.g., Munich: population $= 1,472,000$ inhabitants; surface area $= 310.40$ km^2; population density $= 4742.27$ inhabitants per km^2) of the respective city. We gathered data on the surface area of those locations from the official databases of the national statistical offices. To refine the density score in the replication study, we additionally multiplied each location someone has been living in by the respective years (e.g., Munich: population density $= 4742.27$ inhabitants per km^2; years of living $= 15$; refined density score $= 4742.27 * 15 = 71,134.02$). For some of our subjects, several different locations had been taken together.

2.4. Controls

Our regression models controlled for socio-demographic variables e. g., age and gender and inter-individual differences in personality. Thus, in study 1, we applied the NEO Five-Factor Inventory (German version of the NEO-FFI; Borkenau & Ostendorf, 2008); this is a well-established 60-item questionnaire based on the Five-Factor Model of personality. In the replication study, a short version of the BFI was used (German version of the BFI-S16; John, Donahue, & Kentle, 1991; Rammstedt & John, 2007). Moreover, we included a questionnaire assessing the structure of participants' social networks in the replication study, where we calculated two descriptive metrics of social networks (Cohen, Doyle, Skoner, Rabin, & Gwaltney, 1997): (1) Diversity: participation in nine social groups (e.g., friends, family, church member). One point is assigned for each group (possible score of 9) for which respondents indicate that they participate at least once every 2 weeks. (2) Size: assesses the number of people with whom the individual has regular contact (i.e., at least once every 2 weeks). To calculate network size, we computed the number of people with whom the respondent has regular contact, and then summed them up (14 different categories e.g., relatives, neighbors, work).

2.5. Coding gaze data

Gaze behavior was coded manually frame by frame based on gaze recordings using Tobii Pro Glasses Analyzer (Tobii AB, Sweden). The software allows watching the footage in real time while displaying a superimposed circle depicting the calculated gaze position and defining the beginning and end of each gaze event. To examine participants' eye gaze patterns, we exported the Tobii glasses footage as .mp4 files using Tobii Glasses Analyzer. These audiovisual recordings entail an eye-tracking overlay (red circle), which depict an individual's attentional focus at any time point. We used the standard parameters by the Tobii Analyzer software before exporting our recordings (Rogers, Speelman, Guidetti, & Longmuir, 2018). Specifically, we applied a filter, which interpolated missing points in the recordings with a maximum gap length of 75 ms; noise was reduced by moving median with a window size of 3 samples; velocity was calculated with a window length of 20 ms; the threshold was set at 30°/s; the maximum time between fixations was 75 ms and the maximum angle between fixations was 0.5°; the minimum fixation duration was 60 ms. We did not remove blinks. Coding the video of one participant took 7 h on average, so for our 118 participants, we spent about 830 h of manual coding. Two research assistants, who were unaware of the research hypotheses, coded those eye-tracking recordings. Both coders were thoroughly trained in order to minimize subjectivity and ensure a common standard when coding gaze events that lay between two AoIs (interrater reliability $= R > 89\%$).

To focus on gaze count instead of gaze duration ensured that if during any given frame the eye-tracking overlay was missing because of blinks or technical errors, it would not inflate the measurement of how often each event occurred. However, this remains an issue when

analyzing the duration of gaze events. In order to ensure the reliability of the data and, as the gaze count better reflects attentional orientation (e. g., Emery, 2000; Nummenmaa, Hyönä, & Calvo, 2006), we focused on differences in the number of gaze events. Yet, to examine if our findings could be replicated for social gaze durations for study 2, the occurrence of gaze events was double checked, and we also coded beginning and end of gaze events (see *Supplementary Material*).

To manually code gaze behavior closer to the real-world dynamics of gaze, we focused on raw, unprocessed gaze locations within social regions of the visual field. Classifications of stationary eye-tracking studies do not reflect eye behavior as it naturally occurs in the real world (Lappi, 2016). We operationalized the number of gaze points as the number of gazes *entering* a social region within the visual field, i.e., comprising strangers' faces and bodies (see Fig. 2). We only coded gaze points on bodies and faces within a maximum distance of 7.6 m of our subjects' visual field; this distance represents a close phase in the public context (Hall, 1966). To estimate the relevant coding distance on the eye-tracking recordings, we defined the average size of a person at this distance. The average size of people in the according place was 1.72 m (World Map - Height, 2022). We then transferred this size of the given distance to the resolution of the eye-tracking recordings. Thus, we only included gaze points on passing strangers higher or approximately equal to this respective size.

Although the studies took place in continuously highly frequented department stores, we tried to rule out fluctuations in visitor frequency. Therefore, we conducted the studies only between 10 a.m. and 2 p.m., when, according to the mall administration, visitor numbers reached their daily peak. To further control for the effect of possible fluctuations, we had raters qualitatively rate the number of people in the visual field in study 1 (0 for less frequented, 1 for equally frequented, 2 for more frequented). Although the variable had an effect on gaze counts, as expected ($r = 0.31$, $p = 0.01$, for gaze counts on faces), its impact was independent of the predictive effect for social density in early upbringing (partial correlations for gaze counts on faces and population density, $r = 0.47$, $p < 0.01$, as well as log-transformed population density, $r = 0.39$, $p < 0.01$). Last, we analyzed the eye-tracking data to check whether data quality was comparable across our two samples. We calculated two measures of data quality by summing the total number of gaze points for each participant in the relevant AoIs, and the percentage of gaze samples successfully recorded by the mobile eye-tracker. *T*-Tests for independent samples showed that the two samples did neither differ in the total number of gaze points in faces ($M_1 = 83.70$, $M_2 = 80.21$; $F(2, 116) = 3.34$, $p = 0.32$, $T = 0.46$) nor the percentage of gaze samples ($M_1 = 86.94\%$, $M_2 = 85.81\%$; $F(2, 116) = 1.95$, $p = 0.19$, $T = 0.87$). Yet, the number of gaze points in bodies differed between the two study samples ($M_1 = 127.95$, $M_2 = 102.52$; $F(2, 116) = 11.38$, $p < 0.01$, $T = 4.61$).

Fig. 2. Example of AoIs during the navigation task showing a) an example view of the environment seen by a participant during the navigation task and b) visualization of the AoIs used to analyze relevant gaze points during the task. Note that we did not apply AoIs on the videos, but coders manually coded the relevant AoIs.

3. Results

To test whether urban upbringing in early development predicts the number of gazes at strangers' faces or bodies, we calculated Pearson product-moment correlations in a first step. In a second step, we computed multiple linear regression models to check whether hometown population density explained variance in face-directed gazing beyond socio-demographics and inter-individual differences in personality (Five-Factor Model of personality). Thus, we entered age, gender (Swaab & Swaab, 2009) and the Big Five dimensions of personality (Kingstone et al., 2019; Maran, Furtner, Liegl, Kraus, & Sachse, 2019; Risko, Anderson, Lanthier, & Kingstone, 2012) as control variables into our analyses of study 1. In the analysis of the replication study, we further controlled for individual social network size. In order to reduce the influence of heteroskedasticity, robust standard errors were calculated using the heteroskedasticity consistent estimator 3 (HC3; Davidson & MacKinnon, 1993) in the RLM macro for SPSS (Darlington & Hayes, 2017); standardized coefficients are reported. As the density variable was not normally distributed according to the Shapiro Wilk Test (study 1: $p < 0.01$; study 2: $p < 0.01$), we additionally performed all analyses with a log-transformed density score (lg10 logarithm). Our full datasets are available on Open Science Framework (https://osf.io/vz9b7/). We conducted all statistical analyses in SPSS 26.0.

In study 1, we found that the higher the population density of the place in which subjects grew up, the more often they looked at passing strangers' faces but not their bodies (see Table 1). Multiple linear regression models further revealed that population density explained a substantial proportion of variance in the frequency of gaze points towards other faces after controlling for socio-demographics and the Big Five (see Table 3). Results for gaze-points on bodies are reported in parentheses in the text here. More specifically, the first model encompassing only age and gender did not predict the number of gaze points towards strangers' faces or bodies ($\Delta R^2 = 0.01$, $F(2,63) = 0.31$, $SE = 1.01$, $p = 0.73$). Furthermore, we added the Big Five in a second model; results indicated that personality dimensions neither predicted gaze points towards faces nor bodies ($\Delta R^2 = 0.15$, $F(7,58) = 1.44$, $SE = 0.98$, $p = 0.11$). Finally, hometown population density in early upbringing successfully predicted the frequency of gaze points towards faces and accounted for 12% of variance within the model. When including the log-transformed density score, 10% of variance were explained. By contrast, gaze points towards bodies could not be explained by hometown population density (raw score: $F(8,57) = 1.72$, $p = 0.11$; log-transformed score: $F(8,57) = 1.56$, $p = 0.16$). Therefore, only attention to faces, but not bodies, was influenced by hometown population density in study 1.

Analysis of data from our replication study (study 2) confirmed results from study 1 with both regression models explaining a great proportion of variance in social gaze behavior (see Table 4). Age and gender did neither predict the number of gaze points in faces nor bodies ($\Delta R^2 = 0.01$, $F(2,49) = 0.31$, $SE = 1.01$, $p = 0.74$). However, the addition of the Big Five dimensions into a second model explained 23% variance in faces, but not bodies ($\Delta R^2 = 0.06$, $F(5,44) = 0.55$, $SE = 1.04$, $p = 0.74$). In this replication of our original findings, we additionally wanted to exclude the influence of the size of the current social network and therefore included the social network index in our analyses as a control. Individuals' social network did not account for gaze frequency towards faces or bodies ($\Delta R^2 = 0.08$, $F(2,42) = 0.87$, $SE = 1.01$, $p = 0.56$). In our last model, the raw and log-transformed density scores explained 17% and 15% of variance in facial gaze points, respectively. The frequency of gaze points in bodies could again not be explained (raw score: $\Delta R^2 = 0.03$, $F(1,41) = 1.68$, $SE = 1.00$, $p = 0.20$; log-transformed score: $\Delta R^2 = 0.04$, $F(1,41) = 1.81$, $SE = 1.00$, $p = 0.19$). In addition, in this replication, we have considered and manually coded not only the bodies facing towards our subjects, but also the bodies facing away as an individual AoI. Results of this model show that nearly no variance there could be explained by hometown population density ($\Delta R^2 = 0.06$, $F(5,44) = 0.58$, $SE = 1.02$, $p = 0.72$).

In order to assess the social density of the place where our participants grew up in a more nuanced way, in our replication study, we built a refined measure of hometown population density. We added up each place of residence an individual has been living in during the first 15 years of their life and multiplying it by the years they lived in the respective place. Results showed that this refined score and the gaze points towards faces in the crowd were positively related; by contrast, this was not true for bodies (see Table 2). We then calculated the regression analysis including raw and log-transformed refined density scores (see Table 5). We report the results for gaze-points on bodies in parentheses in the text here. Age and gender neither predicted gaze points towards strangers' faces nor bodies ($\Delta R^2 = 0.01$, $F(2,49) = 0.31$, $SE = 1.01$, $p = 0.74$). The five personality dimensions, however, had an influence on the frequency of facial gaze points within this sample, increasing the explained variance of our model from 4% to 27%. In contrast, interindividual differences in the personality of participants did not explain a significant proportion of the variance in viewpoints on bodies ($\Delta R^2 = 0.06$, $F(5,44) = 0.55$, $SE = 1.04$, $p = 0.74$). Individuals' social network size could not explain gaze frequency towards faces or bodies ($\Delta R^2 = 0.08$, $F(2,42) = 2.18$, $SE = 1.01$, $p = 0.13$). Finally, when adding hometown population density in a fourth model, the explained variance rose from 32% to 50%. The results for the log-transformed density score were similar, showing a rise from 32% to 48% in the explained variance for the frequency of gaze points in faces. Social gazing towards strangers' bodies could not be explained by the raw density

Table 1

Means, standard deviations, and Pearson product-moment correlations among the two measures of hometown population density, socio-demographics (3.–4.), the five personality measures (5.–9.), and the two measures of social gaze behavior (10.–11.) of study 1.

	M(SD)	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Density (raw)	1130 (1214)										
2. Density (log)	2.78 (0.54)	0.860***									
3. Age	22.88 (2.75)	0.058	0.034								
4. Gender[a]	0.47 (0.50)	0.178	0.165	0.008							
5. Neuroticism	2.46 (0.59)	−0.138	−0.141	−0.026	−0.170	(0.83)					
6. Extraversion	3.89 (0.47)	−0.120	−0.123	0.037	−0.220	−0.203	(0.79)				
7. Openness	3.74 (0.56)	0.195	0.118	0.120	0.141	−0.072	0.300*	(0.78)			
8. Agreeableness	3.84 (0.53)	0.020	−0.032	0.132	−0.088	−0.094	0.449***	0.212	(0.81)		
9. Conscientiousness	3.46 (0.58)	0.027	−0.019	0.109	−0.163	−0.380**	0.165	0.181	0.166	(0.84)	
10. Face Gaze Points	83.69 (43.39)	0.424***	0.373**	−0.026	0.072	−0.061	−0.010	0.277*	0.127	−0.106	
11. Body Gaze Points	44.26 (30.09)	0.202	0.155	0.094	−0.031	0.091	0.259*	0.250*	0.161	−0.107	0.132

Note. $N = 66$; reliabilities are presented along the diagonal in parentheses.

[a] Dummy variable (0 = male, 1 = female).

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

Table 2

Means, standard deviations, and Pearson product-moment correlations among the two measures of hometown population density, socio-demographics (3.–4.), the five personality measures (5.–9.), and the two measures of social gaze behavior (10.–11.) of the replication study.

	M(SD)	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. Density (simple)	1052 (1284)												
2. Density (refined)	17,708 (21,601)	0.915***											
3. Age	24.54 (6.08)	0.058	0.064										
4. Gender[a]	0.40 (0.50)	0.123	0.051	−0.093									
5. Neuroticism	3.69 (1.44)	0.062	0.190	0.039	−0.358**	(0.82)							
6. Extraversion	5.31 (1.04)	0.063	0.097	0.148	−0.132	−0.222	(0.86)						
7. Openness	5.47 (0.93)	−0.037	0.013	0.094	−0.226	−0.044	0.158	(0.67)					
8. Agreeableness	5.19 (0.89)	0.170	0.105	0.289*	−0.113	−0.038	−0.028	0.025	(0.54)				
9. Conscientiousness	4.94 (1.17)	−0.031	−0.097	0.257	−0.207	−0.062	0.268	0.188	0.380**	(0.79)			
10. Social Network	27.29 (9.19)	0.074	0.135	0.269	0.000	−0.148	0.099	0.099	0.272	0.252			
11. Social Groups	4.29 (2.15)	−0.131	−0.038	0.057	0.017	0.077	0.317*	0.022	−0.072	0.222	0.388**		
12. Face Gaze Points	80.21 (36.87)	0.503***	0.509***	0.054	0.191	−0.186	0.112	−0.218	0.189	−0.240	0.230	−0.137	
13. Body Gaze Points	22.31 (18.65)	−0.214	−0.206	0.067	−0.094	−0.011	0.114	0.195	−0.095	−0.044	0.237	0.237	−0.156

Note. $N = 52$; reliabilities are presented along the diagonal in parentheses.

[a] Dummy variable (0 = male, 1 = female).

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

score ($\Delta R^2 = 0.06$, $F(1,41) = 3.07$, $SE = 0.99$, $p = 0.09$). By contrast, when we included the log-transformed density score, the measure explained a significant proportion of the variance in viewpoints on bodies ($\Delta R^2 = 0.09$, $F(1,41) = 4.97$, $SE = 0.97$, $p = 0.03$). Differences in results for personality might be due to the different questionnaires applied in both studies. While the NEO-FFI in study 1 comprises 60 items and therefore assesses each personality dimension more broadly, in study 2, we used an economic measure of the OCEAN personality model, the BFI-S16 comprising only 16 items.

Only a few participants came from metropolises and stood out as visual outliers (density score above 3800 inhabitants per km^2). Yet, effects for both studies remained constant even after removing them from the analyses (study 1: raw density score: $\Delta R^2 = 0.08$, $F(1,53) = 5.36$, $SE = 0.92$, $p = 0.02$; log-transformed density score: $\Delta R^2 = 0.06$, $F(1,53) = 3.96$, $SE = 0.93$, $p = 0.052$; study 2: raw density score: $\Delta R^2 = 0.17$, $F(1,41) = 3.79$, $SE = 0.80$, $p < 0.01$; log-transformed density score: $\Delta R^2 = 0.15$, $F(1,41) = 3.58$, $SE = 0.81$, $p < 0.01$). For study 2, we also analyzed the duration of gaze events and replicated the results from the models with the number of gaze points (see *Supplementary Material* for detailed statistics).

In summary, our results show that hometown population density predicts the frequency of gaze points towards faces in two independent samples; the places someone spent most of their life before late adolescence strongly impact social gaze behavior in crowded areas (see Fig. 3).

4. Discussion

Our lives are increasingly centralized in urban spaces. Yet, to date, we know little about how the experience of growing up and living in crowded areas affects our social lives (e.g., Dye, 2008). In the present study, we shed light on urban upbringings' effects on a cornerstone of social functioning: social attention (Lederbogen et al., 2011; Lederbogen et al., 2013). Therefore, we investigated how urbanicity in early lifetime

Table 3

Results of the regression analyses, assessing the additional variance in gaze points towards other faces explained by the inclusion of the *simple* population density score (Model 3) in comparison to models containing socio-demographics (Model 1) and the five factors of personality (Model 2) in study 1.

	Study 1[a]			Study 1[b]
	Model 1	Model 2	Model 3	Model 3
Socio-demographics				
Age	−0.03 (0.18)	−0.06 (0.13)	−0.07 (0.12)	−0.07 (0.15)
Gender	0.07 (0.13)	−0.07 (0.16)	−0.09 (0.16)	−0.09 (0.16)
Psychological Traits				
Neuroticism		−0.16 (0.18)	−0.10 (0.17)	−0.10 (0.18)
Extraversion		−0.20 (0.18)	−0.11 (0.15)	−0.13 (0.15)
Openness		0.35 (0.14)*	0.26 (0.15)	0.30 (0.14)*
Agreeableness		0.17 (0.14)	0.14 (0.13)	0.16 (0.14)
Conscientiousness		−0.23 (0.16)	−0.21 (0.15)	−0.20 (0.16)
Urban Upbringing				
Population Density			0.37 (0.13)**	0.33 (0.13)*
R^2 (adjusted)	0.01 (0.00)	0.15 (0.05)	0.27 (0.17)	0.25 (0.14)
F-statistic	$F(2,63) = 0.19$	$F(7,58) = 1.47$	$F(8,57) = 2.68$*	$F(8,57) = 2.35$*

Note. $N = 66$. Standardized coefficients are reported.

Robust standard errors (HC3) are displayed in parentheses.

[a] Raw score.

[b] Log-transformed score.

* $p < 0.05$.

** $p < 0.01$.

Table 4
Results of the regression analyses, assessing the additional variance in gaze points towards other faces explained by the inclusion of the *simple* population density score (Model 4) in comparison to the models containing socio-demographics (Model 1), the five factors of personality (Model 2), and the social network (Model 3) in the replication study.

	Study 2[a]				Study 2[b]
	Model 1	Model 2	Model 3	Model 4	Model 4
Socio-demographics					
Age	0.07	0.05	0.02	0.02	0.02
	(0.14)	(0.14)	(0.12)	(0.12)	(0.12)
Gender	0.20	0.10	0.10	0.00	0.00
	(0.14)	(0.15)	(0.16)	(0.13)	(0.14)
Psychological Traits					
Neuroticism		−0.12	−0.08	−0.17	−0.12
		(0.15)	(0.17)	(0.13)	(0.13)
Extraversion		0.24	0.18	0.11	0.13
		(0.14)	(0.15)	(0.13)	(0.13)
Openness		−0.18	−0.19	−0.19	−0.20
		(0.14)	(0.15)	(0.12)	(0.12)
Agreeableness		0.34	0.27	0.18	0.20
		(0.15)*	(0.13)	(0.14)	(0.14)
Conscientiousness		−0.40	−0.37	−0.34	−0.34
		(0.15)*	(0.15)*	(0.14)*	(0.14)*
Social Network			0.25	0.21	0.23
			(0.16)	(0.14)	(0.14)
Social Groups			−0.14	−0.07	−0.07
			(0.15)	(0.13)	(0.13)
Urban Upbringing					
Population Density				0.43	0.41
				(0.12)**	(0.12)**
R^2 (adjusted)	0.04	0.27	0.32	0.48	0.47
	(0.00)	(0.16)	(0.17)	(0.35)	(0.34)
F-statistic	$F(2,49)$ = 1.06	$F(7,44)$ = 2.35*	$F(9,42)$ = 2.15*	$F(10,41)$ = 3.79**	$F(10,41)$ = 3.58**

Note. $N = 52$. Standardized coefficients are reported.
Robust standard errors (HC3) are displayed in parentheses.
[a] Raw score.
[b] Log-transformed score.
* $p < 0.05$.
** $p < 0.01$.

Table 5
Results of the regression analyses, assessing the additional variance in gaze points towards other faces explained by the inclusion of the *refined* population density score (Model 4) in comparison to the models containing socio-demographics (Model 1), the five factors of personality (Model 2), and the social network (Model 3) in the replication study.

	Study 2[a]				Study 2[b]
	Model 1	Model 2	Model 3	Model 4	Model 4
Socio-demographics					
Age	0.07	0.05	0.02	0.02	0.01
	(0.14)	(0.14)	(0.12)	(0.12)	(0.12)
Gender	0.20	0.10	0.10	0.01	0.02
	(0.14)	(0.15)	(0.16)	(0.13)	(0.13)
Psychological Traits					
Neuroticism		−0.12	−0.08	−0.24	−0.16
		(0.15)	(0.17)	(0.13)	(0.13)
Extraversion		0.24	0.18	0.08	0.08
		(0.14)	(0.15)	(0.13)	(0.13)
Openness		−0.18	−0.19	−0.21	−0.19
		(0.14)	(0.15)	(0.12)	(0.12)
Agreeableness		0.34	0.27	0.19	0.21
		(0.15)*	(0.13)	(0.13)	(0.14)
Conscientiousness		−0.40	−0.37	−0.29	−0.31
		(0.15)*	(0.15)*	(0.13)	(0.14)
Social Network			0.25	0.18	0.23
			(0.16)	(0.14)	(0.14)
Social Groups			−0.14	−0.10	−0.07
			(0.15)	(0.13)	(0.13)
Urban Upbringing					
Population Density				0.47	0.43
				(0.12)**	(0.12)**
R^2 (adjusted)	0.04	0.27	0.32	0.50	0.48
	(0.00)	(0.16)	(0.17)	(0.38)	(0.35)
F-statistic	$F(2,49)$ = 1.06	$F(7,44)$ = 2.35*	$F(9,42)$ = 2.15*	$F(10,41)$ = 4.16**	$F(10,41)$ = 3.73**

Note. $N = 52$. Standardized coefficients are reported.
Robust standard errors (HC3) are displayed in parentheses.
[a] Raw score.
[b] Log-transformed score.
* $p < 0.05$.
** $p < 0.01$.

influences our attention towards social encounters. In two studies, we tracked the gaze behavior of people while walking through crowded shopping malls using mobile eye-tracking glasses. More specifically, we recorded how our participants naturalistically attended to other people in crowded environments. Findings suggest that urban upbringing does indeed configure social gaze behavior in crowded areas. Our results show that people with experience of city living in early upbringing look more often at the faces of others in crowds than those, who grew up in rural areas. In fact, while controlling for the influence of socio-demographics and psychological traits, population density in early life predicted between 12% (study 1) and 18% (replication study 2) of the variance in gazes towards faces of passing strangers in close proximity. Interestingly, urban upbringing affected only attention to the face, but neither to the body of those strangers nor to averted people passing by. Our findings add a puzzle piece to the picture of how early city living shapes social cognition and gives rise to the question why living in cities affects the way we look at social encounters.

Three explanatory approaches aligned with the functions of social gaze behavior could offer an answer to these findings (Risko et al., 2016). First, gaze behavior is a tool to gather information in our sensory environment. Our data show that urbanicity in early upbringing specifically increases attention to the face region. Considering that our participants navigated through social crowds, we argue that the need to disambiguate encounters' intentions could have driven heightened attention towards faces. Living in socially dense areas is accompanied by the repeated experience of the invasion of one's personal space. Limits of appropriate social distance are violated continuously (Hall, 1966). Being

faced with this violation of social norms might prompt the need to decipher the intruder's intentions in order to avoid potentially harmful closeness. The facial region is the most important and reliable source of information about the intentions of other people (e.g., Kobayashi & Kohshima, 1997; Laidlaw et al., 2012). Even the eye region alone is sufficient to infer internal mental states such as emotions in other people (e.g., Baron-Cohen, 1997; Emery, 2000; Kingstone et al., 2019). Paying more attention to faces might thus reflect the developed response of urban dwellers to decipher intentions of intruding others and reduce mistrust in the face of invasion in crowded spaces (Lemmers-Jansen, Fett, van Os, Veltman, & Krabbendam, 2020). Urbanicity-related bias towards more social attention in crowds may thus be an early adaptation configured to deal most effectively with the social ambiguity inherent in human crowds (Grossmann, 2017) and to engender successful navigation through the dense social environment of urban spaces. This is supported by recent evidence reporting volume and activity changes in brain regions in urban dwellers compared to rural dwellers (e.g., Haddad et al., 2015; Neale et al., 2020). Living in cities is associated with greater amygdala volume (Kühn et al., 2017) and altered amygdala activity when faced with social stress (Lederbogen et al., 2011). These changes and our findings as a possible consequence could be the result of a repeated infringement of personal space and in particular a repeated exposure to strangers in cities, which trigger the brains' threat system, thus facilitating chronic engagement of the amygdala (e.g., Hoffmann, Maran, & Sachse, 2020; Lederbogen et al., 2011). This reveals an interesting convergence, as the same brain region seems in fact relevant both for interpersonal space sensitivity (Kennedy & Adolphs, 2014) and
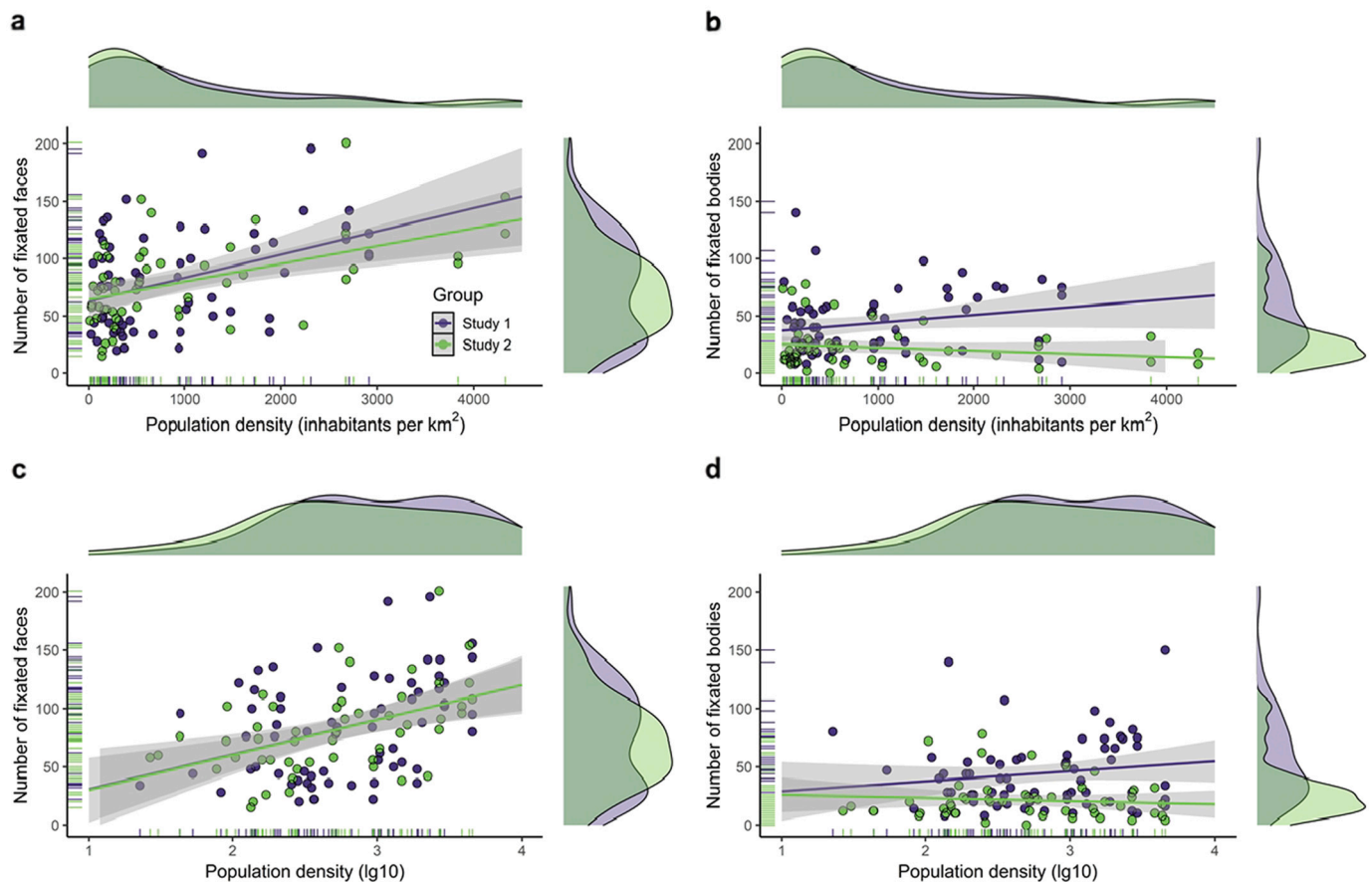
Fig. 3. Early life experience in urbanicity and its association with social gaze behavior in human crowds. Correlations are displayed between population density (simple raw score: A/B; simple log-transformed score: C/D) and the frequency of gaze points towards faces (left) and bodies (right), respectively; standardized values (study 1: $N = 66$; study 2: $N = 52$) are displayed with linear regressions and a 95% confidence interval. Histograms on either side of the graphs denote relative frequency distributions.

for the control of eye-movements in threat detection (Adolphs, 2008; de Gelder et al., 2014).

The second explanatory approach considers another major function of social gaze behavior beyond information gathering, particularly social signaling (Rogers et al., 2018). The human eye has a particular morphology that seems to have evolved specifically to facilitate social communication. It has the most prominent whites of any primate species and is horizontally elongated (Kobayashi & Kohshima, 1997), making it possible for others to observe what we are attending to (Emery, 2000). This unique morphology transforms the eye as a tool to communicate, as it acts as a signal to which receivers react (e.g., Siposova, Tomasello, & Carpenter, 2018). This signaling function should particularly manifest under naturalistic conditions e.g., in the real presence of others, just like in our setting (Gobel et al., 2015). However, how might this signaling function explain why urban dwellers are more likely to pay attention to faces in crowds than others? Again, one plausible explanation could be rooted in the aforementioned repeated experience of intrusions into one's personal space. Experiencing a stranger directly inside our personal space may not only lead to the need to decipher their intentions, as described before. We argue that, in addition, an individual also might exhibit a signal to communicate that there is no threat from him- or herself. There is evidence that individuals *spontaneously* employ covert attention rather than direct looking (Dosso, Huynh, & Kingstone, 2020; Kuhn, Teszka, Tenaw, & Kingstone, 2016), which might be useful when strangers are further away. If two people get too close to each other in a crowded space, they might also want to signal that they have no harmful intentions by looking overtly at the other. In fact, looking at each other elicits positive feelings (Hietanen, 2002), favorable first impressions

(Maran et al., 2019), and actually engenders cooperation (Bateson, Nettle, & Roberts, 2006), prosocial behavior (Ekström, 2012), and honesty (Nettle, Nott, & Bateson, 2012). Children as young as five to seven signal cooperative intentions to each other simply by looking at each other (Siposova et al., 2018). Therefore, social gaze behavior might serve as a signal to defuse the situation when we are faced with personal space invasion. Unlike rural dwellers, those who grew up in cities might repeatedly have been exposed to such experiences and therefore exhibit such behavior more often.

Third, our findings show that lower social density in the early developmental environment predicts fewer gazes at the faces of passing strangers in crowds. Decreased social attention in individuals, who grew up in rural areas could also be a protective mechanism to prevent cognitive overload. Unlike those, who grew up as urban dwellers, people living in rural areas were less exposed to such crowds during their lifetime. The social environment of a crowded shopping mall is rich in social information that is difficult to interpret and integrate cognitively. In particular, social encounters that might result in mutual gazing could cause cognitive interference (Conty, Gimmig, Belletier, George, & Huguet, 2010; Doherty-Sneddon & Phelps, 2005). It is well established that such social stimuli can interfere with cognitive processes and thus disrupt fluid thinking (Kajimura & Nomura, 2016). This can be observed in children as young as 8 years old, as they avoid eye gaze to prevent distraction during tasks (Beuckels, De Jans, Cauberghe, & Hudders, 2021). Since those, who grew up in rural areas may not be as familiar with navigating through crowds, their avoidance of social gaze behavior could also be a strategy to manage cognitive load. In other words, our results may reflect the fact that people with early experience of city life

are adapted to gather and process social information in crowds more efficiently than their rural counterparts. Specifically, the social information that people convey through their faces and inform about their intentions. This notion finds support in recent evidence indicating that city dwellers do in fact process faces differently than people from rural areas (Balasz & Saville, 2015). This approach, which considers the capability of social cognition, could be an exciting avenue for related research. Although our design refrains from touching on this point, connecting urban upbringing with social attention may inspire overdue research on the link between urbanicity and social cognitive functioning, in particular, the potential vulnerabilities that can arise from such lifelong exposure to social crowds and a mass of social information. Interestingly, specifically those mental disorders that are linked to urbanicity are characterized by a severe dysfunction of social cognition (e.g., Breslau, Marshall, Pincus, & Brown, 2014; Meyer-Lindenberg, 2010; Mortensen et al., 1999).

Although a strength of our research is its ecological validity, we would like to discuss some limitations. First, individuals are prone to alter their real-world gaze behavior while wearing eye-tracking glasses, as knowing that their gaze is being monitored makes them feel more self-conscious about where they are looking at (Foulsham et al., 2011). Risko and Kingstone (2011) manipulated whether individuals thought that their gaze was being monitored or not, when being confronted with a provocative stimulus (poster of a naked woman). When individuals did not feel monitored, they usually looked at this stimulus; when they knew that their gaze behavior was tracked, they attended less frequently. The effect of being watched is thus likely to have a particular impact on our participants' gaze behavior. For example, they could have tried to avoid staring at other people. On the other hand, they move in a naturalistic environment with the real presence of other people, therefore others can perceive their gaze behavior anyway. Second, we focus on social density as a core characteristic of urban life. Yet, cities are also characterized by other attributes, such as increased noise or less green space. Both of these attributes of cities actually have an impact on psychological functioning (Kou, Tao, Kwan, & Chai, 2020; Ojala, Korpela, Tyrväinen, Tiittanen, & Lanki, 2019). However, there are accessible descriptive data for both characteristics; with a larger sample, future research could also consider such factors. Third, as our results only reflect Western patterns of social gaze behavior, we have to be cautious in drawing conclusions about how urbanicity affects social attention in Eastern cultures. Indeed, important cultural differences exist in how individuals in different cultures display gaze behaviors towards others (Akechi et al., 2013; McCarthy, Lee, Itakura, & Muir, 2006). Fourth, the same also applies to socio-demographics and psychographics. It has been shown that the dynamics of social attention, especially in naturalistic settings, differ between genders as well as age groups and are also linked to personality traits (Swaab & Swaab, 2009; Risko et al., 2012; de Lillo et al., 20214). Although we control for age, gender, and personality traits, our research was not designed to specifically test for such differences (e.g., too narrow range at age). A recent study indeed found age differences concerning social attention in real-world settings (de Lillo et al., 2021).

Fifth, our findings depicted a specific situation i.e., a shopping mall. Just like riding an elevator or bus, this is a very crowded situation where participants have to navigate through a mass of strangers. The equilibrium approach to the classic finding that people in elevators compensate for the scarcity of space and crowded standing with other nonverbal contacts (e.g., Zuckerman et al., 1983) would predict a general avoidance of eye contact in such a shopping mall. One could argue that in such situations this is truer for rural than for urban natives, who are used to such situations. In other words, it could still be the case that in other, less crowded situations both rural and urban natives show different gaze patterns than those we find, and therefore our findings are specific to that shopping mall situation. Sixth, the available stimuli in a social environment might influence how frequently such stimuli might be looked at. More specifically, the more social encounters happen, the

more individuals might look towards passing strangers. We collected our data in a constantly crowded area, but we did not count the available social stimuli in the visual field of our participants. Although our study was conducted in a real social situation and is therefore characterized by ecological validity, it is still the case that future studies should quantify social presence more precisely (see de Lillo et al., 2021).

5. Conclusion

Two field studies show that urbanicity predicts naturalistic attention to passing strangers in crowded shopping malls. Urban natives show more gazes towards their social counterparts than rural natives. These results indicate that urban upbringing might channel its own attentional pilot system to navigate through urban social life. This study adds to the sparse body of existing research on the psychological consequences of urbanization, highlighting city living as a distinct factor that shapes our social functioning. Our findings also gain significance in the light of the fact that urbanicity is associated with a number of severe psychiatric disorders that are specifically characterized by a breakdown of social cognition. Thus, given the contemporary demographic trend towards increasing urbanization of human life and initial findings on its consequences, there is a need for better understanding the emergence of an urban mind and the way it operates.

Data availability

Data is available on Open Science Framework (https://osf.io/vz9b7/).

CRediT authorship contribution statement

Thomas Maran: Conceptualization, Methodology, Investigation, Resources, Writing – original draft, Writing – review & editing, Supervision, Project administration. **Alexandra Hoffmann:** Formal analysis, Data curation, Writing – original draft, Writing – review & editing, Visualization. **Pierre Sachse:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no conflict of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cognition.2022.105099.

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