Article

Seeing racial avoidance on New York City streets

Bryce J. Dietrich ⓘ [1] ✉ & Melissa L. Sands ⓘ [2] ✉

Here, using publicly available traffic camera feeds in combination with a real-world field experiment, we examine how pedestrians of different races behave in the presence of racial out-group members. Across two different New York City neighbourhoods and 3,552 pedestrians, we generate an unobtrusive, large-scale measure of inter-group racial avoidance by measuring the distance individuals maintain between themselves and other racial groups. We find that, on average, pedestrians in our sample (93% of whom were phenotypically non-Black) give a wider berth to Black confederates, as compared with white non-Hispanic confederates.

In the United States and elsewhere, race is a salient feature of everyday social interactions. Though places of residence, work and study remain highly segregated along racial lines, with white Americans especially isolated from Black Americans, some degree of racial contact is particularly unavoidable in cities[1]. Whether they occur on the street, on public transit or in other public spaces, these encounters need not involve conversation or verbal exchange to be impactful. Social scientists have long argued that Americans behave differently in the presence of racial out-group members than they do in encounters with their in-group, and in a way that reflects a torrid history of institutionalized racism and segregation. Even as the majority of Americans now reject explicitly racist messages[2,3], and as individuals' willingness to express racist attitudes on surveys has generally declined over time[4], white Americans' behaviour belies persistent racial biases. This behaviour need not be obviously discriminatory; racial bias may in fact be more apparent in subtle, non-verbal spontaneous behaviours than in more explicit behaviours[5–7].

One such behaviour is racial avoidance. Researchers have observed non-verbal, physical manifestations of racial bias in the context of social conversations[8], seating distance[9] and shared space invasion[10]. Prior studies have, however, largely relied on laboratory or relatively small-scale field studies that employ qualitative or coarse measurement techniques. This study contributes a large-scale field experiment-based approach to studying racial bias in pedestrian interactions in highly naturalistic scenarios and settings. Using publicly available, real-time video feeds from New York City Department of Transportation (NYC DOT) traffic cameras (https://nyctmc.org//), combined with confederates of different races, we address a central social science question: how do members of different racial groups behave towards each other

in commonplace public encounters? In particular, we examine how members of different groups navigate one another on the sidewalks of a major city, one of the few places where inter-racial encounters regularly occur.

In this Article, we experimentally manipulate the presence of phenotypically Black and phenotypically white young adult males on sidewalks in Manhattan, and measure the behaviour of pedestrians who pass by our confederates. Our measurement technique uses NYC DOT traffic cameras to passively record pedestrian movements vis-à-vis the confederates. Our findings support our hypothesis that, on average, pedestrians will give a wider berth to phenotypically Black males than they do to phenotypically white non-Hispanic males.

This study offers several major contributions. Substantively, we document that pedestrians in the United States actively avoid Black Americans on sidewalks, which probably imposes a psychological toll on a population already heavily burdened with historical and institutionalized racism. Although we are not the first to suggest such a relationship, we do so using a large field experiment in a common and important naturalistic setting. Not only do our design and measurement strategies make our findings more generalizable than previous studies, but they also allow us to uncover subtle changes in walking trajectories, which underscores one of the many ways implicit biases are physically manifested in everyday behaviour. We demonstrate one way scholars could study such behaviour from afar without costly surveys. Video camera feeds are available in many cities throughout the country, and researchers may even set up their own cameras to systematically measure behaviour. By combining a field experiment with publicly available 'big data', we demonstrate the virtue of blending careful research design with widely available high-frequency data.

[1]Department of Political Science, Purdue University, West Lafayette, IN, USA. [2]Department of Government, London School of Economics and Political Science, London, UK. ✉e-mail: bjdietri@purdue.edu; m.sands@lse.ac.uk

Social scientists have long described social behaviour in terms of physical space[11]. People utilize space in their environment in ways that reflect their attitudes towards others[12]. A large body of research—most prominently work on construal level theory[13]—describes a powerful link between social or psychological distance and physical distance[14,15]. Individuals tend to describe friends and in-group members as 'close' and strangers and out-group members as 'distant'[16]—a phenomenon so pervasive that it has even been observed in young children[17]. Physical distance is not only central to how individuals speak about others, it affects how people reason about and perceive physical distances between themselves and out-groups[18–21]. The tendency to equate out-groups with 'distant' manifests in non-verbal behaviours, most notably physical avoidance. For example, white Americans put more space between themselves and Black Americans in conversation than they do when speaking with fellow whites[8,22]. Another form of avoidance is seating distance, which has been used by social psychologists as a measure of racial bias in laboratory settings[23,24].

Inter-racial encounters have been a topic of academic interrogation since at least the middle of the twentieth century[25]. Neighbourhood racial composition influences individuals' behaviour[26,27]. In the now vast body of literature that includes observational and experimental studies of racial contact and threat[28–30], less attention has been paid to one of the most basic and common types of encounters—those that regularly occur on sidewalks and street corners. These experiences are substantively important because they are quintessentially public and nearly universal.

Here we focus on pedestrians. Early work on spatial displacement on sidewalks and in public spaces emphasizes dominance behaviour[31–33] and its evolutionary roots[34], personal space[35] and 'gallantry'[36,37]. Scholars have focused on gender differences as a determinant of both power and gallantry in pedestrian encounters[31,37–39]. Other features that determine how pedestrians are treated include group size, occupational uniform, age, physical weakness or disability, attractiveness and cultural differences[40]. Though researchers have described various inter-personal behaviours between Black and white individuals and used physical avoidance as both an indicator of prejudice and as a measure of discrimination, studies of inter-racial pedestrian interaction are rare. Nearly 40 years ago, researchers examined responses to breaches in spatial etiquette by studying what happens when Black confederates overtly violate social norms by blocking pedestrians' way[10]. We consciously depart from this paradigm with a more subtle and naturalistic intervention that is designed to reflect an everyday scenario: confederates conform to social norms by standing out of the way of pedestrian traffic, behaving as unimposing bystanders on public sidewalks.

Our study leverages an unobtrusive measure of individual-level behaviour—live public camera feeds from the city of New York—to understand interactions that are not typically systematically observed. Images from these cameras, which allow NYC DOT staff and the public to monitor live traffic conditions throughout NYC, were recorded for later processing. The research sites are situated in two different Manhattan neighbouhoods: the more residential Upper East Side and more commercial Midtown East.

Three experimental conditions were implemented and recorded at each site. In the first condition, two young phenotypically white adult male confederates stood facing each other, in conversation, in a designated spot within camera view for 15 min. In the second condition, a pair of young phenotypically Black adult male confederates took their place—standing in the same spots, such that the distance between them was equidistant across race conditions—for the same period of time. In the third (baseline) condition, no confederates were present for the same period of time, recorded the same way as in the first two conditions.

Confederates in each pair were dressed similarly to those in the other pair, and were similar in height, weight and age, such that between-pair differences were minimized. Steps were taken to ensure
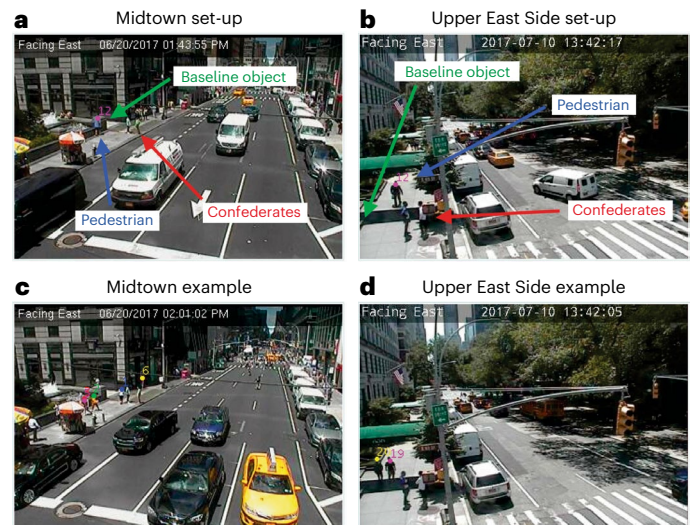
Fig. 1 | Experiment set-up and example tracking images. a–d, Camera images from Midtown (**a** and **c**) and Upper East Side (**b** and **d**) locations. The original images were provided by the NYC DOT (© 2017. New York City Department of Transportation. All rights reserved), examples of which can be found online (https://www.nyc.gov/html/dot/html/home/home.shtml). In the top row, confederates are referenced in red, pedestrians in blue and the baseline object in green. Pedestrians in all images are numbered for the purpose of manual tracking. All markings are not on the original images.

that confederates behaved identically across conditions. They were instructed to talk about the same, non-political topic and monitored to make sure that they did not deviate from this protocol. As shown in Fig. 1, confederates were positioned such that they created a slight bottleneck that funnels pedestrians into the treatment area without obstructing their movement.

Results

Figure 2 shows the average treatment effect (ATE) of the presence of Black confederates in both locations (black), on the Upper East Side (dark grey) and in Midtown (light grey). Our main outcome measure ('standardized pedestrian deviation', SPD) reflects the deviation of a pedestrian from the confederate location as a proportion of the sidewalk width, as detailed in Supplementary Information Section 3.3. In Fig. 2, the left includes all pedestrians, while the right includes only those identified as non-Black. In the top of Fig. 2, each ATE reflects a simple difference-in-means, calculated by estimating a bivariate ordinary least squares (OLS) regression of SPD on an indicator for whether the confederates present are phenotypically Black. In the bottom of Fig. 2, covariate-adjusted ATEs (CTE) are reported, with controls for pedestrian race and gender, 45 min time block and indicators for pedestrians travelling in groups or pairs on the Upper East Side and for pedestrian race and time block in Midtown. Thicker and thinner lines reflect 90% and 95% confidence intervals (CIs), respectively, bootstrapped to account for dependence within 15 min clusters (the unit at which randomization occurred) using a wild block bootstrap[41]. Note that this approach is highly conservative: though clustered standard errors are appropriate when clusters of units, rather than individual units, are assigned to treatment[42], in our set-up it is implausible that pedestrians receiving treatment towards the end of a 15 min time block are dependent on those treated at the beginning.

Across both locations, estimated treatment effects are generally consistent with pedestrian avoidance of Black confederates relative to white. On the left of Fig. 2, pooling across the two neighbourhoods, pedestrians deviate by, on average, 3.43% of the sidewalk width ($t_{3,417} = 2.403$, $P = 0.016$, $\beta = 0.032$, $CI_{95\%}$ 0.006 to 0.059 without controls; $t_{3,322} = 5.167$, $P < 0.001$, $\beta = 0.034$, $CI_{95\%}$ 0.021 to 0.047 with controls), or
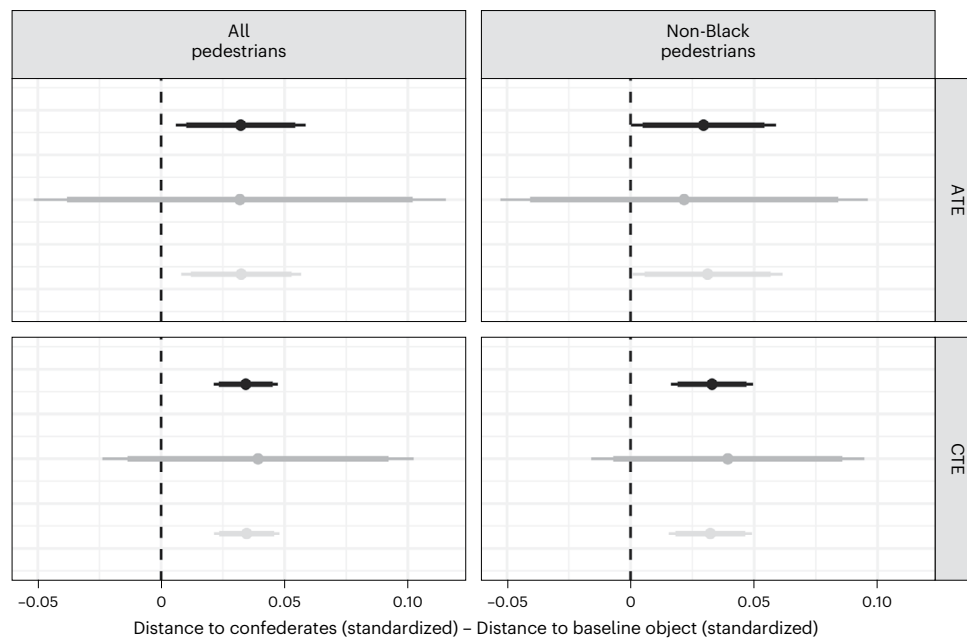
Fig. 2 | Pedestrians give a wider berth to Black confederates. Treatment effects from OLS regressions of SPD on an indicator for whether the confederates present are Black (versus white). The top graphs (ATE) reflect simple differences-in-means, while the bottom (CTE) include controls for pedestrian characteristics and time block fixed effects. Positive values indicate deviation from Black confederates relative to white confederates as a proportion of total sidewalk width. Black denotes both locations (N_{all} = 3,419; $N_{non-Black}$ = 3,208), while dark grey and light grey correspond to the Upper East Side (N_{all} = 516; $N_{non-Black}$ = 448) and Midtown (N_{all} = 2,903; $N_{non-Black}$ = 2,758), respectively. For the Upper East Side, all variables other than the treatment indicator were coded by a graduate RA at a later date (Supplementary Information Section 5.1). There were also six pedestrians in the Upper East Side who were identified as outliers by the same RA. Although these are excluded in this figure, their inclusion does not change our substantive results (Supplementary Information Section 5.4). Thicker and thinner lines represent 90% and 95% CIs, respectively, bootstrapped to account for dependence within 15 min clusters. All reported statistical tests are two tailed. Table 1 reports the full statistical results, including all coefficients, P values and CIs.

around 4 inches, in the presence of Black confederates. On the Upper East side, estimated effects do not attain statistical significance at conventional levels; point estimates reflect that pedestrians move away between 3.19% and 3.93% of the sidewalk width (t_{514} = 0.751, P = 0.453, β = 0.032, CI$_{95\%}$ −0.052 to 0.115 without controls; t_{424} = 1.223, P = 0.222, β = 0.039, CI$_{95\%}$ −0.024 to 0.102 with controls), or between 3.1 and 3.8 inches, but are too noisy to reject the null hypothesis of no racial avoidance. In Midtown, pedestrians deviate between 3.24% and 3.47% of the sidewalk width ($t_{2,901}$ = 2.620, P = 0.009, β = 0.032, CI$_{95\%}$ 0.008 to 0.057 without controls; $t_{2,895}$ = 5.128, P < 0.001, β = 0.035, CI$_{95\%}$ 0.021 to 0.048 with controls), amounting to between 4.1 and 4.4 inches.

When subsetting to non-Black pedestrians, who make up 93% of our sample, our results do not meaningfully change. On the right of Fig. 2, when pooling across the two neighbourhoods, point estimates reflect that non-Black pedestrians move away between 3.30% and 3.70% of the sidewalk width ($t_{3,241}$ = 1.972, P = 0.049, β = 0.030, CI$_{95\%}$ <0.001 to 0.059 without controls; $t_{3,149}$ = 3.890, P < 0.001, β = 0.033, CI$_{95\%}$ 0.016 to 0.050 with controls), or between 3.8 and 4.3 inches. On the Upper East side, point estimates reflect that non-Black pedestrians move away between 2.17% and 3.94% of the sidewalk width (t_{483} = 0.473, P = 0.567, β = 0.022, CI$_{95\%}$ −0.053 to 0.096 without controls; t_{396} = 1.400, P = 0.162, β = 0.039, CI$_{95\%}$ −0.016 to 0.095 with controls), or between 3.8 and 6.6 inches, but only the latter estimated effect attains statistical significance at conventional levels. In Midtown, non-Black pedestrians deviate between 3.20% and 3.22% of the sidewalk width ($t_{2,756}$ = 2.015, P = 0.044, β = 0.031, CI$_{95\%}$ 0.001 to 0.062 without controls; $t_{2,751}$ = 3.762, P < 0.001, β = 0.032, CI$_{95\%}$ 0.015 to 0.049 with controls), or around 4 inches, in the presence of Black confederates.

Additional pre-registered hypotheses are also tested in Table 1. These include hypotheses that the wider berth predicted by the racial avoidance hypothesis will be more pronounced in predominantly white neighbourhoods (neighbourhood out-group salience) and among white pedestrians (pedestrian out-group salience). Comparing 'all pedestrians' to 'non-Black pedestrians' in the 'both locations' subsection, we find no meaningful difference in the berth given by non-Black pedestrians as compared with all others. We also find essentially no difference between our Upper East Side and Midtown locations. Thus, we find very little support for our neighbourhood and pedestrian out-group salience hypotheses. For a more detailed discussion, please refer to Supplementary Information Section 5.5.

Finally, we expected all pedestrians would move further away from our confederates as compared with the baseline object (obstruction avoidance). We also expected that women would move further away from our male confederates as compared with men (gender heterogeneity). Supplementary Information Section 5.5 explains each of these hypotheses more fully. We find strong statistical support for the first hypothesis, meaning pedestrians move significantly further away from our confederates ($t_{3,417}$ = 5.710, P < 0.001, β = 7.549, CI$_{95\%}$ 4.957 to 10.140 without controls; $t_{3,322}$ = 5.704, P < 0.001, β = 7.561, CI$_{95\%}$ 4.962 to 10.159 with controls). We also find support for our gender heterogeneity hypothesis, with women moving further away from our confederates as compared with men (t_{226} = 1.713, P = 0.088, β = 4.883, CI$_{95\%}$ −0.735 to 10.501 without controls; t_{226} = 3.862, P < 0.001, β = 11.272, CI$_{95\%}$ 5.510 to 17.035 with controls). However, we were only able to test the gender heterogeneity hypothesis using our Upper East Side location, so it is unclear the extent to which this result is generalizable.

Discussion

Our findings are indicative of racial avoidance. Even in a highly stimulating and densely populated locale, pedestrians systematically change their behaviour in observable ways in the presence of racial out-groups. The effects we measure may in fact represent a lower bound; if such behaviour is detectable in New York City, pedestrian racial avoidance is probably even more pervasive in more racially conservative

Table 1 | Treatment effects for New York City sidewalk experiment

| | Black Confederates | | | | |
	Present ($\hat{\beta}$)	t-Statistic	d.f.	P value	95% CI
Both locations					
All pedestrians					
With controls	0.034	5.167	3,322	<0.001	(0.021 to 0.047)
Without controls	0.032	2.403	3,417	0.016	(0.006 to 0.059)
Non-Black pedestrians					
With controls	0.033	3.890	3,149	<0.001	(0.016 to 0.050)
Without controls	0.030	1.972	3,241	0.049	(<0.001 to 0.059)
Upper East Side					
All pedestrians					
With controls	0.039	1.223	424	0.222	(−0.024 to 0.102)
Without controls	0.032	0.751	514	0.453	(−0.052 to 0.115)
Non-Black pedestrians					
With controls	0.039	1.400	396	0.162	(−0.016 to 0.095)
Without controls	0.022	0.573	483	0.567	(−0.053 to 0.096)
Midtown					
All pedestrians					
With controls	0.035	5.128	2,895	<0.001	(0.021 to 0.048)
Without controls	0.032	2.620	2,901	0.009	(0.008 to 0.057)
Non-Black pedestrians					
With controls	0.032	3.762	2,751	<0.001	(0.015 to 0.049)
Without controls	0.031	2.015	2,756	0.044	(0.001 to 0.062)

Note: treatment effects from OLS regressions of SPD on an indicator for whether the confederates present are Black (versus white). Positive values indicate deviation from Black confederates relative to white confederates as a proportion of total sidewalk width. ATEs are shown in the rows labelled 'without controls.' In the rows labelled 'with controls', we condition the treatment effect on pedestrian characteristics and time block fixed effects. All statistical tests are two tailed, and CIs are bootstrapped to account for dependence within 15 min clusters.

environments. Moreover, we isolate this effect both with and without controls, suggesting our results are not dependent on specific model corrections.

These findings comport with our pre-registered hypotheses and are consistent with well-established theories of out-group bias and threat, as well as evidence that young Black men in particular are stereotyped as threatening[43–45]. They are also consistent with evidence from across the social sciences that who and what we encounter as we move through space matters for a wide range of political and social outcomes. An experience as seemingly trivial as passing someone of another race or social class on a city sidewalk can have meaningful implications for decision making[46].

Links between non-verbal measures of prejudice and more explicit behavioural indicators of racism are well established. Physical avoidance in particular has been shown to track racial bias in the laboratory. For example, researchers have used immersive virtual environments to demonstrate that implicit prejudice against an ethnic out-group (as measured by an implicit attitude test) predicts avoidance behaviour[47], and that racial avoidance behaviour (inter-personal distance and head orientation in a virtual encounter) predicts aggressiveness and hostility towards Black males in a subsequent virtual gunfight[48]. This body of work suggests that what is at stake is much more than a few inches of sidewalk space. One alternative interpretation of our findings is that pedestrians are 'giving people space' rather than avoiding them. We reject this interpretation, and point to the literature on proxemics, which focuses on how people use space during social interactions, and demonstrates physical avoidance of stigmatized groups in a variety of contexts, linking patterns of avoidance to implicit measures of prejudice (for a review, see ref. 49).

Our study remains subject to several limitations. As is the case in most field studies, research subjects do not represent a random sample of the population. Pedestrians on our selected Manhattan street corners are likely to be wealthier, better educated and more politically left-leaning than the average American. These traits may or may not make subjects less prone to racial avoidance. Technical and feasibility constraints limit our ability to estimate pedestrian race and perfectly measure actual physical distances in the camera feeds. Future research might make use of high-definition video feeds now available in other locales, or researchers might employ their own cameras.

Our study also carries important implications. First, we document systematic racial avoidance in the real world, a finding that is highly consistent with the narratives voiced by people of colour, for whom stereotype threat[50] and 'micro-aggressions' carry pernicious consequences[51]. Avoidance experienced by Black individuals, day in and day out, probably imposes a psychological toll on a population that already carries the extra burden of historical and institutionalized racism, eroding mental and physical health. Moreover, pedestrian racial avoidance can be both a cause and consequence of misattributions of threat. The very public, widespread and chronic occurrence of pedestrian racial avoidance may have spillover effects that influence others' behaviour in subtle but destructive ways[52]. For example, law enforcement—even if trained to recognize their own implicit biases—may implicitly or explicitly detect bystander behaviour and overestimate the level of threat posed by Black Americans in ambiguous situations.

Second, we develop a method that allows researchers to study mass pedestrian behaviour in the real world, and that can be used anywhere that cameras capture pedestrians in their feeds. Openly accessible video feeds are increasingly ubiquitous, yet under-utilized

as a research tool[53]. By combining our measurement strategy with field experiments, future scholars can replicate our study in different neighbourhoods and with different confederate characteristics, such as socio-economic status, gender, ethnicity and age.

Methods

This research complies with all relevant ethical regulations, and received approval from the University of Iowa Institutional Review Board (protocol no. 201706768), with a reliance issued by the University of California, Merced Institutional Review Board. In doing so, we asked for informed consent to be waived. This was done for three reasons. First, we use publicly available camera feeds that record pedestrians every day without obtaining informed consent, meaning there is not the same expectation of privacy in this setting as opposed to in settings such as research laboratories. Second, the facial features of specific pedestrians are nearly impossible to discern from camera images. This, in addition to the way the results are reported—in the aggregate—means there is limited risk for the pedestrians involved. Finally, obtaining consent would have required stopping pedestrians, which is invasive and probably infeasible.

Traffic cameras in the Upper East Side and Midtown neighbourhoods were selected on the basis of several factors: visibility of a large swath of unobstructed sidewalk, camera angle and image quality. These neighbourhoods and the camera selection process are described in Supplementary Information Section 2.

The conditions were block randomized to control for natural fluctuations in pedestrian flow that occur throughout the day, such as lunchtime and commuting hours. That is, each day was divided into 45 min blocks, and the order in which the three conditions were implemented within a block was randomized. The experiment took place over the course of two weekdays. On the first day, five 45 min blocks were implemented in immediate succession at a pre-determined location in Midtown. On the second day, the same procedure was repeated—and the order re-randomized—at the Upper East Side location. Finally, all measurements were taken from distinct samples using two-sided tests.

As the experiment occurred, a research assistant (RA) on site unobtrusively identified phenotypically Black pedestrians as they passed the fixed confederate location, a task that was independently validated for one site using the recorded video, as detailed in Supplementary Information, Section 5.1. On the basis of a power analysis informed by a pilot study conducted at a different intersection in Manhattan, we established and pre-registered a target sample size of 1,350 pedestrians over 225 min of video. Ultimately we recorded 225 min at each location, capturing 776 pedestrians on the Upper East Side and 4,632 in Midtown. Of the 776 pedestrians identified on the Upper East Side (by condition: $N_{Black} = 253$, $N_{white} = 263$, $N_{control} = 260$), 48 (by condition: $N_{Black} = 9$, $N_{white} = 17$, $N_{control} = 22$) were said to be Black or African American by our RA on the day of the experiment. This same RA identified 230 phenotypically Black pedestrians in Midtown (by condition: $N_{Black} = 57$, $N_{white} = 88$, $N_{control} = 85$), representing 4.97% of the 4,632 pedestrians tracked at that location (by condition: $N_{Black} = 1,447$, $N_{white} = 1,456$, $N_{control} = 1,729$). In Supplementary Information Section 5.2 we show balance in the proportion of Black pedestrians across experimental treatments. In Supplementary Information Section 5.1.2 we also present analyses of inter-coder reliability with respect to the pedestrian race coding. All confederates and RAs were blind to the researcher hypotheses.

Recovering measurements from a photograph, or from any two-dimensional representation of a three-dimensional world, is difficult due to well-known features of perspective: objects appear smaller as distance from the observer increases, and perceived distance is distorted by the angle of vision. Thus, in a given frame of video, on the portion of sidewalk towards the top of the image (further away from the camera) a single pixel represents a greater distance than a pixel towards the bottom of an image (closer to the camera). As a pedestrian moves along the sidewalk, the relationship between pixels and actual distance on the ground changes as they progress from background to foreground. The nature of this dynamic relationship, furthermore, is dependent on the camera angle and zoom, which differs by location. Most relevant for our study, measuring the actual distance between individuals on a sidewalk is complicated by distortions due to the cameras' angled position, rather than it being located directly overhead. Although we cannot solve this problem, we take steps to show that it does not invalidate our experimental findings.

As pre-registered, we consider the relationship between the pedestrian and a neutral, baseline object, located on the other edge of the sidewalk, directly adjacent and parallel to the confederates. For each frame of video, we subtract the distance (in pixels) from a given pedestrian to that object ('baseline distance') from the distance from that pedestrian to the confederate ('confederate distance'). This value is a rough proxy for how far a pedestrian is from the confederate location relative to the baseline object when the three points appear on the same visual plane.

We provide evidence of the validity of this approach in Supplementary Information Section 3.4. This validation exercise is on the basis of the idea that a camera located directly above the confederates, providing a 'bird's eye view', yields the equivalent of a two-dimensional representation of the scene; from this view, one could directly measure distances from the confederates to pedestrians without distortions due to camera angle or perspective. As described in more detail in Supplementary Information Section 3, we use agent-based modelling and three-dimensional models of our experimental locations to demonstrate that the SPD yields the same results regardless of whether images reflect the original camera angle or a 'bird's eye view' in an animated simulation. The ATEs calculated using these two camera perspectives are nearly identical, suggesting that our measurement approach is appropriate in the context of a randomized experiment.

Since distortions due to perspective are minimized when a pedestrian is on the same visual plane as the confederates, we use only the measurement for each pedestrian that is closest to the confederate location in our main model specifications. We pre-registered our intent to use only the closest observation, and anticipated using pixel distance to identify the closest observation. However, we discovered when implementing a validation exercise suggested by a reviewer, that using pixel distance for this purpose does not always reveal the pedestrian observation that is closest in actual distance. Thus, we use 'closest point' frames identified by RAs, as detailed in Supplementary Information Section 3.5. The accuracy and reliability of these visual assessments is demonstrated in Supplementary Information Section 5.1.3. We also show in Supplementary Information Section 4 that our findings are not sensitive to the decision to use a single observation for each pedestrian; models utilizing all observations for each pedestrian yield the same substantive conclusions.

Pedestrians were manually tracked on the recorded camera images using the Fiji distribution of ImageJ. We consider only pedestrians who crossed between the confederates and the baseline object, and focus on those who are within close proximity to, and are not separated by a physical barrier from, the confederates. The set-up, measurement strategy and manual tracking protocol are further detailed in Supplementary Information Section 3.

Our main outcome measure (SPD) is explained in greater detail in Supplementary Information Section 3.3 and reflects the deviation of a pedestrian from the confederate location as a proportion of the sidewalk width. We standardize by sidewalk width—126 and 96.5 inches wide at the Midtown and Upper East Side locations, respectively—to make results from the two sites more comparable, as pedestrian behaviour is in part dependent on the amount of room one has to manoeuvre. To obtain estimates of pedestrian avoidance in inches, we divide the pedestrian deviation in pixels by the pixel width of the sidewalk, and then use the actual sidewalk width at the plane at which the confederates are standing to convert that percentage to inches. Note that the

main specifications involve comparisons between the Black and white conditions only; data from the pure control (no confederate) condition are not used. In Supplementary Information Section 5.5.1 we discuss these results, which demonstrate how pedestrian behaviour changes in the presence of confederate of either race relative to a baseline object. All statistical tests are two tailed.

Protocol registration: study design and hypotheses were registered with Evidence in Governance and Politics: http://egap.org (ID no. 20170616AA) on 16 June 2017. Our pre-registration plan can be found at this URL: https://osf.io/vtqez (accessed on 11 August 2020).

Photographs in Fig. 1 are used with permission of the City of New York (© 2017. New York City Department of Transportation. All rights reserved).

Reporting summary

Further information on research design is available in the Nature Portfolio Reporting Summary linked to this article.

Data availability

All data necessary to replicate the analyses and figures in this paper and supporting information are available at https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/Y9QEUK.

Code availability

All code necessary to replicate the analyses and figures in this paper and supporting information are available at https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/Y9QEUK. R (open source, version 4.1.0) was used for data analysis.

References

1. Wang, Q., Phillips, N. E., Small, M. L. & Sampson, R. J. Urban mobility and neighborhood isolation in America's 50 largest cities. *Proc. Natl Acad. Sci. USA* **115**, 7735–7740 (2018).
2. Kinder, D. R. & Sanders, L. M. *Divided by Color: Racial Politics and Democratic Ideals* (Univ. of Chicago Press, 1996).
3. Hutchings, V. L., Valentino, N. A., Philpot, T. S. & White, I. K. The compassion strategy: race and the gender gap in campaign 2000. *Public Opin. Q.* **68**, 512–541 (2004).
4. Schuman, H., Steeh, C., Bobo, L. & Krysan, M. *Racial Attitudes in America: Trends and Interpretations* (Harvard Univ. Press, 1997).
5. Dovidio, J. F., Kawakami, K. & Gaertner, S. L. Implicit and explicit prejudice and interracial interaction. *J. Pers. Soc. Psychol.* **82**, 62 (2002).
6. Dovidio, J. F., Kawakami, K., Johnson, C., Johnson, B. & Howard, A. On the nature of prejudice: automatic and controlled processes. *J. Exp. Soc. Psychol.* **33**, 510–540 (1997).
7. Word, C. O. et al. The nonverbal mediation of self-fulfilling prophecies in interracial interaction. *J. Exp. Soc. Psychol.* **10**, 109–120 (1974).
8. Willis, F. N. Initial speaking distance as a function of the speakers' relationship. *Psychon. Sci.* **5**, 221–222 (1966).
9. Hendricks, M. & Bootzin, R. Race and sex as stimuli for negative affect and physical avoidance. *J. Soc. Psychol.* **98**, 111–120 (1976).
10. Brown, C. E. Shared space invasion and race. *Pers. Soc. Psychol. Bull.* **7**, 103–108 (1981).
11. Bogardus, E. S. A social distance scale. *Sociol. Soc. Res.* **17**, 265–271 (1933).
12. Hall, E. T. & Hall, T. *The Silent Language* Vol. 948 (Anchor Books, 1959).
13. Liberman, N., Sagristano, M. D. & Trope, Y. The effect of temporal distance on level of mental construal. *J. Exp. Soc. Psychol.* **38**, 523–534 (2002).
14. Bar-Anan, Y., Liberman, N., Trope, Y. & Algom, D. Automatic processing of psychological distance: evidence from a stroop task. *J. Exp. Psychol.* **136**, 610 (2007).
15. Matthews, J. L. & Matlock, T. Understanding the link between spatial distance and social distance. *Soc. Psychol.* **42**, 185 (2011).
16. Hoxter, A. L. & Lester, D. Social distance evaluations in white and african-american students. *Percept. Mot. Skills* **80**, 478 (1995).
17. Koslin, S. C., Amarel, M. & Ames, N. A distance measure of racial attitudes in primary grade children: an exploratory study. *Psychol. Sch.* **6**, 382–385 (1969).
18. Gatrell, A. C. *Distance and Space: A Geographical Perspective* (Oxford Univ. Press, 1983).
19. Kerkman, D. D., Stea, D., Norris, K. & Rice, J. L. Social attitudes predict biases in geographic knowledge. *Prof. Geogr.* **56**, 258–269 (2004).
20. Maddox, K. B., Rapp, D. N., Brion, S. & Taylor, H. A. Social influences on spatial memory. *Mem. Cognit.* **36**, 479–494 (2008).
21. Enos, R. D. *The Space between Us: Social Geography and Politics* (Harvard Univ. Press, 2016).
22. Aiello, J. R. & Jones, S. E. Field study of the proxemic behavior of young school children in three subcultural groups. *J. Pers. Soc. Psychol.* **19**, 351 (1971).
23. Kawakami, K., Phills, C. E., Steele, J. R. & Dovidio, J. F. (Close) distance makes the heart grow fonder: improving implicit racial attitudes and interracial interactions through approach behaviors. *J. Pers. Soc. Psychol.* **92**, 957 (2007).
24. Goff, P. A., Steele, C. M. & Davies, P. G. The space between us: stereotype threat and distance in interracial contexts. *J. Pers. Soc. Psychol.* **94**, 91 (2008).
25. Key, Jr, V. O. *Southern Politics in State and Nation* (Knopf, 1949).
26. Massey, D. S. & Denton, N. A. *American Apartheid: Segregation and the Making of the Underclass* (Havard Univ. Press, 1993).
27. Trounstine, J. Segregation and inequality in public goods. *Am. J. Pol. Sci.* **60**, 709–725 (2015).
28. Allport, G. W. *The Nature of Prejudice* (Basic Books, 1979).
29. Enos, R. D. What the demolition of public housing teaches us about the impact of racial threat on political behavior. *Am. J. Pol. Sci.* **60**, 123–142 (2016).
30. Enos, R. D. Causal effect of intergroup contact on exclusionary attitudes. *Proc. Natl Acad. Sci. USA* **111**, 3699–3704 (2014).
31. Dabbs Jr, J. M. & Stokes III, N. A. Beauty is power: the use of space on the sidewalk. *Sociometry* **38**, 551–557 (1975).
32. Knowles, E. S. Boundaries around group interaction: the effect of group size and member status on boundary permeability. *J. Pers. Soc. Psychol.* **26**, 327 (1973).
33. Henley, N. *Body Politics: Power, Sex, and Nonverbal Communication* (Prentice Hall, 1977).
34. Washburn, S. L. & DeVore, I. The social life of baboons. *Sci. Am.* **204**, 62–71 (1961).
35. Evans, G. W. & Howard, R. B. Personal space. *Psychol. Bull.* **80**, 334 (1973).
36. Goffman, E. *Relations in Public: Microstudies of the Social Order* (Allen Lane, 1971).
37. Willis, F. N., Gier, J. A. & Smith, D. E. Stepping aside: correlates of displacement in pedestrians. *J. Commun.* **29**, 34–39 (1979).
38. Silveira, J. Thoughts on the politics of touch. *Women's Press* **1**, 13 (1972).
39. Sobel, R. S. & Lillith, N. Determinants of nonstationary personal space invasion. *J. Soc. Psychol.* **97**, 39–45 (1975).
40. Thayer, S. & Alban, L. A field experiment on the effect of political and cultural factors on the use of personal space. *J. Soc. Psychol.* **88**, 267–272 (1972).
41. Cameron, A. C., Gelbach, J. B. & Miller, D. L. Bootstrap-based improvements for inference with clustered errors. *Rev. Econ. Stat.* **90**, 414–427 (2008).
42. Abadie, A., Athey, S., Imbens, G. W. & Wooldridge, J. *When Should You Adjust Standard Errors for Clustering?* Technical Report (National Bureau of Economic Research, 2017).

43. Cottrell, C. A. & Neuberg, S. L. Different emotional reactions to different groups: a sociofunctional threat-based approach to 'prejudice'. *J. Pers. Soc. Psychol.* **88**, 770 (2005).

44. Harris-Lacewell, M. No place to rest: African American political attitudes and the myth of black women's strength. *Women Polit.* **23**, 1–33 (2001).

45. Goff, P. A., Jackson, M. C., Di Leone, B. A. L., Culotta, C. M. & DiTomasso, N. A. The essence of innocence: consequences of dehumanizing Black children. *J. Pers. Soc. Psychol.* **106**, 526 (2014).

46. Sands, M. L. Exposure to inequality affects support for redistribution. *Proc. Natl Acad. Sci. USA* **114**, 663–668 (2017).

47. Dotsch, R. & Wigboldus, D. H. J. Virtual prejudice. *J. Exp. Soc. Psychol.* **44**, 1194–1198 (2008).

48. McCall, C., Blascovich, J., Young, A. & Persky, S. Proxemic behaviors as predictors of aggression towards Black (but not white) males in an immersive virtual environment. *Soc. Influ.* **4**, 138–154 (2009).

49. McCall, C. in *Social Behavior from Rodents to Humans* (eds Wöhr, M. & Krach, S.) 295–308 (Springer, 2015).

50. Steele, C. M. *Whistling Vivaldi: How Stereotypes Affect Us and What We Can Do* (W. W. Norton & Company, 2011).

51. Sue, D. W. et al. Racial microaggressions in everyday life: implications for clinical practice. *Am. Psychol.* **62**, 271 (2007).

52. Weisbuch, M., Pauker, K. & Ambady, N. The subtle transmission of race bias via televised nonverbal behavior. *Science* **326**, 1711–1714 (2009).

53. Dietrich, B. J. in *Exploring the C-SPAN Archives: Advancing the Research Agenda* (ed. Browning, R. X.) 241–258 (Purdue Univ. Press, 2016).

Author contributions

B.J.D. and M.L.S. contributed equally to the authorship of this manuscript.

Competing interests

The authors declare no competing interests.

Additional information

Supplementary information The online version contains supplementary material available at https://doi.org/10.1038/s41562-023-01589-7.

Correspondence and requests for materials should be addressed to Bryce J. Dietrich or Melissa L. Sands.

Peer review information *Nature Human Behaviour* thanks Christopher Marshburn and the other, anonymous, reviewer(s) for their contribution to the peer review of this work.

Reprints and permissions information is available at www.nature.com/reprints.

nature portfolio

Corresponding author(s): Melissa Sands, Bryce Dietrich

Last updated by author(s): 1 March 2022

Reporting Summary

Nature Portfolio wishes to improve the reproducibility of the work that we publish. This form provides structure for consistency and transparency in reporting. For further information on Nature Portfolio policies, see our Editorial Policies and the Editorial Policy Checklist.

Statistics

For all statistical analyses, confirm that the following items are present in the figure legend, table legend, main text, or Methods section.

n/a	Confirmed	
☐	☒	The exact sample size (*n*) for each experimental group/condition, given as a discrete number and unit of measurement
☐	☒	A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
☐	☒	The statistical test(s) used AND whether they are one- or two-sided *Only common tests should be described solely by name; describe more complex techniques in the Methods section.*
☐	☒	A description of all covariates tested
☐	☒	A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons
☐	☒	A full description of the statistical parameters including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals)
☐	☒	For null hypothesis testing, the test statistic (e.g. *F*, *t*, *r*) with confidence intervals, effect sizes, degrees of freedom and *P* value noted *Give P values as exact values whenever suitable.*
☒	☐	For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
☐	☒	For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
☐	☒	Estimates of effect sizes (e.g. Cohen's *d*, Pearson's *r*), indicating how they were calculated

Our web collection on statistics for biologists contains articles on many of the points above.

Software and code

Policy information about availability of computer code

Data collection	All data was collected using Python (version 3.5.3) and the R statistical software language (version 4.1.0).
Data analysis	All analyses were conducted using the R statistical software language (version 4.1.0).

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio guidelines for submitting code & software for further information.

Data

Policy information about availability of data

All manuscripts must include a data availability statement. This statement should provide the following information, where applicable:
- Accession codes, unique identifiers, or web links for publicly available datasets
- A description of any restrictions on data availability
- For clinical datasets or third party data, please ensure that the statement adheres to our policy

All data and code necessary to replicate the analyses and figures in this paper and supporting information are available at https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/Y9QEUK.

Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☐ Life sciences   ☒ Behavioural & social sciences   ☐ Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see nature.com/documents/nr-reporting-summary-flat.pdf

Behavioural & social sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description	This is a real-world field experiment of inter-group racial avoidance in two different New York City neighborhoods. Using publicly-available traffic camera feeds, we operationalize this concept by measuring use the distance individuals maintain between themselves and other racial groups.
Research sample	Pedestrians walking on two New York City sidewalks comprised our sample. Conditions were block randomized to control for natural fluctuations in pedestrian flow that occur throughout the day, such as lunchtime and commuting hours. All blocks were 45-minutes long.
Sampling strategy	The experiment took place over the course of two weekdays. On the first day, five 45-minute blocks were implemented in immediate succession at a pre-determined location in Midtown. On the second day, the same procedure was repeated – and the order re-randomized – at the Upper East Side location. We used the results from a small pilot study to conduct several power calculations in order to determine our final sample size.
Data collection	Data was collected by caching images from two New York City traffic cameras. Manual tracking was then completed using ImageJ. Pedestrian demographic information was coded in real-time by on-site research assistants. Additional pedestrian information was provided by another RA watching the videos at a later date.
Timing	The data were collected on two days: June 20, 2017 and July 10, 2017.
Data exclusions	Only pedestrians who walked by our confederates are included in the study.
Non-participation	Since we are tracking all pedestrians as they walk down the study sidewalks, this is not applicable. However, please see our "Data exclusions" statement.
Randomization	Conditions were block randomized. Please our "Research Sample" and "Sampling Strategy" statements.

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

Materials & experimental systems

n/a	Involved in the study
☒	Antibodies
☒	Eukaryotic cell lines
☒	Palaeontology and archaeology
☒	Animals and other organisms
☐	☒ Human research participants
☒	Clinical data
☒	Dual use research of concern

Methods

n/a	Involved in the study
☒	ChIP-seq
☒	Flow cytometry
☒	MRI-based neuroimaging

Human research participants

Policy information about studies involving human research participants

Population characteristics	See above.
Recruitment	Participants are pedestrians naturally walking down our study sidewalks, so no recruitment was necessary.
Ethics oversight	Our experimental design was pre-registered with EGAP (Evidence in Governance and Politics) and registered on June 16, 2017 (ID# 20170616AA). The University of Iowa Institutional Review Board (IRB) approved our proposed design on August 3, 2017 (IRB ID# 201706768). Although the New York City Department of Transportation (NYCDOT) traffic cameras are fully

public, we entered into a data-use agreement between NYCDOT and the University of California, Merced and the University of Iowa on October 19, 2020.

Note that full information on the approval of the study protocol must also be provided in the manuscript.