Abstract

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 neighborhoods 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 give a wider berth to black confederates, as compared to white non-Hispanic confederates, an effect that is primarily driven by non-black pedestrians.
Introduction

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 African Americans, some degree of racial contact is particularly unavoidable in cities (Wang et al., 2018). 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 significant. 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 (e.g. Kinder, 1996; Hutchings et al., 2004), and as individuals’ willingness to express racist attitudes on surveys has generally declined over time (e.g. Sears and Kinder, 1971; Sears, 1988), white Americans’ behavior belies persistent racial biases. This behavior need not be obviously discriminatory; racial bias may in fact be more apparent in subtle, nonverbal spontaneous behaviors than in more explicit behaviors (Dovidio, Kawakami and Gaertner, 2002; Dovidio et al., 1997; Word et al., 1974).

One such behavior is racial avoidance. Researchers have observed nonverbal, physical manifestations of racial bias in the context of social conversations (Willis, 1966), seating distance (Hendricks and Bootzin, 1976), and shared space invasion (Brown, 1981). Prior studies have, however, largely relied on laboratory or relatively small scale field studies that employ qualitative or coarse measurement techniques, and none have systematically studied pedestrian racial avoidance. This study contributes a new, 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 (http://dotsignals.org/), combined with confederates of different races, we address a central social science question: How do
members of different racial groups behave toward 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 interracial encounters regularly occur.

Experimentally, we manipulate the presence of phenotypically black and phenotypically white young adult males on sidewalks in Manhattan, and measure the behavior 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. We find that, on average, pedestrians give a wider berth to African American males than they do to white non-Hispanic males.

This study offers several major contributions. Substantively, we document that pedestrians in the United States actively avoid African Americans on sidewalks. Despite the surfeit of social science evidence that speaks to the consequences of individual-level intergroup exposure, extant studies tend to face a number of challenges: selection bias or sorting, social desirability or experimenter bias, and questionable generalizability outside the laboratory. By randomizing the presence of racial out-group members in a real world setting, and by utilizing an entirely noninvasive measurement strategy, we directly surmount these challenges. Methodologically, we offer a new set of tools for studying everyday behavior without surveys and from afar. Video camera feeds are available in many cities throughout the country, and researchers may even set up their own cameras to systematically measure behavior. By combining a field experiment with publicly available “big data,” we demonstrate the virtue of combining careful research design with widely-available high-frequency data.

Background

Beginning with [Bogardus, 1933] social scientists have described social behavior in terms of physical space. People utilize space in their environment in ways that reflect their attitudes towards others [Hall and Hall, 1959]. A large body of research – most prominently work
on construal level theory (Liberman, Sagristano and Trope, 2002) – describes a powerful link between social or psychological distance and physical distance (Bar-Anan et al., 2007; Matthews and Matlock, 2011). Individuals tend to describe friends and in-group members as “close” and strangers and out-group members as “distant” (Hoxter and Lester, 1995) – a phenomenon so pervasive that it has even been observed in young children (Koslin, Amarel and Ames, 1969). 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 (Gatrell, 1983; Kerkman et al., 2004). The tendency to equate out-groups with “distant” manifests in nonverbal behaviors, 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 (Willis, 1966; Aiello and Jones, 1971). Another form of avoidance is seating distance, which has been used by social psychologists as a measure of racial bias in laboratory settings (Kawakami et al., 2007; Goff, Steele and Davies, 2008).

Interracial encounters have been a topic of academic interrogation since at least the middle of the twentieth century, when Key (1949) argued that neighborhood racial composition influences individuals’ behavior (e.g. Massey and Denton, 1993; Massey, 1993; Trounstine, 2015). In the now vast body of literature that includes observational and experimental studies of racial contact (Allport, 1979; Enos, 2016, 2014) and threat, 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 uniquely significant 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 behavior (Dabbs Jr and Stokes III, 1975; Knowles 1973; Henley, 1977) and its evolutionary roots (Washburn and DeVore, 1961), personal space (Evans and Howard, 1973), and “gallantry” (Goffman, 1971; Willis, Gier and Smith, 1979). Scholars have focused on gender differences as a determinant of both power and gallantry in
pedestrian encounters (Silveira, 1972; Dabbs Jr and Stokes III, 1975; Sobel and Lillith, 1975; Willis, Gier and Smith, 1979). Other features that determine how pedestrians are treated include group size, occupational uniform, age, physical weakness or disability, attractiveness, and cultural differences (Thayer and Alban, 1972). Though researchers have described various interpersonal behaviors between black and white individuals and used physical avoidance as both an indicator of prejudice and as a measure of discrimination, studies of interracial pedestrian interaction are rare.

**Research Design**

Our study leverages an unobtrusive measure of individual-level behavior—live NYC 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, with permission, for later processing. The research sites are situated in two different Manhattan neighborhoods: the more residential Upper East Side and more commercial Midtown East. In these neighborhoods, traffic cameras were selected based on several factors: visibility of a large swath of unobstructed sidewalk, camera angle and image quality. These neighborhoods and the camera selection process are described in Appendix S1.

Three experimental conditions were implemented and recorded at each site. In the first condition, two phenotypically white young adult male confederates stood facing each other, in conversation, in a designated spot within camera view for 15 minutes. In the second condition, a pair of phenotypically black young 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. As shown
in, Figure 1, confederates were positioned such that they created a bottleneck which funnels pedestrians into the treatment area without fully obstructing their movement.

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-minute 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-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.

As the experiment occurred, a research assistant 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 Appendix S5.3. In this way, racial information was imputed for all 786 pedestrians on the Upper East Side, and for 3,007 out of 3,887 (77%) in Midtown. Research assistants identified 201 phenotypically black pedestrians in Midtown and 49 in the Upper East Side. In Appendix S5.1 we show balance in the proportion of black pedestrians across experimental conditions.

Measurement

Recovering measurements from a photograph, or from any two-dimensional representation of a three-dimensional world, requires understanding the relationship between distance in a three-dimensional space and the pixels observed in a two-dimensional image. This is 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 toward 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
Figure 1: Experiment Set-Up and Example Tracking Images

(a) Midtown Set-Up

(b) Upper East Side Set-Up

(c) Midtown Example

(d) Upper East Side Example

Note: Camera images from Midtown (panels A and C), and Upper East Side (panels B and D) locations. 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.
to foreground. The nature of this dynamic relationship, furthermore, is dependent on the camera angle and zoom, which differs by location.

To ameliorate this problem, 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 reflects how far a pedestrian is from the confederate location relative to the baseline object. As the pedestrian passes between the confederate location and the baseline object the measurement error associated with the confederate distance is roughly equivalent to the measurement error associated with the baseline distance because the three points appear on the same visual plane.

As pre-registered, we use only the measurement for each pedestrian that is closest to the confederate location in our main model specifications, minimizing the error due to visual distortions. We show in Appendix S3 that our findings are not sensitive to this measurement decision; 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 setup, measurement strategy, and manual tracking protocol are further detailed in Appendix S2.

Our main outcome measure (“standardized pedestrian deviation”, or SPD) 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 behavior is in part dependent on the amount of room one has to maneuver. 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 Appendix S5.2 we discuss these results, which demonstrate how pedestrian behavior changes in the presence of confederates of either race.

Findings

Figure 2 presents 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), respectively. The leftmost panel includes all pedestrians, while the rightmost includes only those identified as non-black. In the top panels, each ATE reflects a simple difference-in-means, calculated by estimating a bivariate OLS regression of SPD on an indicator for whether the confederates present are phenotypically black or not. The bottom panels report covariate-adjusted average treatment effects (CTE), with controls for pedestrian race and gender, 45-minute time block, and indicators for pedestrians traveling 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, respectively, bootstrapped to account for dependence within 15-minute clusters (the unit at which randomization occurred) using a wild block bootstrap (Cameron, Gelbach and Miller, 2008). 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 (Abadie et al., 2017), in our setup it is implausible that pedestrians receiving treatment towards the end of a 15-minute time block are dependent on those treated at the beginning. In Appendix S3, we show that alternative standard error adjustments accounting for shorter time periods generate narrower confidence intervals.

Across both locations and all specifications, estimated treatment effects are positive, indicating pedestrian avoidance of black confederates relative to white. Pooling across the two neighborhoods, pedestrians deviate by, on average, 3.3% of the sidewalk width ($t = 2.29, p = 0.02$ without controls, $t = 4.69, p = 0.0000028$ with controls), or around 4 inches, in
Note: Treatment effects from OLS regressions of standardized pedestrian deviation on an indicator for whether the confederates present are black (versus white). The top panels (ATE) reflect simple differences-in-means while the bottom panels (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 \(N_{all} = 3552; N_{non-black} = 3328\), while dark grey (■■) and light grey (■□) correspond to the Upper East Side \(N_{all} = 517; N_{non-black} = 486\) and Midtown \(N_{all} = 3033; N_{non-black} = 2877\), respectively. Thicker (—) and thinner (—–) lines represent 90 and 95-percent confidence intervals, bootstrapped to account for dependence within 15-minute clusters.
the presence of black confederates. On the Upper East side, pedestrians move away between 4.6% and 6.2% of the sidewalk width ($t = 1.13, p = 0.26$ without controls, $t = 1.93, p = 0.055$ with controls), or between 4.5 and 6 inches. In Midtown, pedestrians deviate by around 3% of sidewalk width ($t = 2.44, p = 0.015$ without controls, $t = 4.49, p = 0.0000007$ with controls), on average, amounting to about 4 inches.

When subsetting to non-black pedestrians, these results generally strengthen, despite diminished sample sizes. The CTEs in the bottom righthand panel range from 3.4% of the sidewalk in Midtown ($t = 5.77, p = 0.000000009$) to 7.0% on the Upper East Side ($t = 2.43, p = 0.015$) reflecting distances of 4.3 to 6.7 inches, respectively. In Appendix S5 we report results from a number of alternative measurement specifications, all of which support the same substantive conclusions.

**Discussion and Conclusion**

Our findings are indicative of racial avoidance. Even in a highly-stimulating, densely populated, and politically left-leaning locale pedestrians systematically change their behavior in observable ways in the presence of racial out-groups. This phenomenon replicates across two very different settings, one largely residential and other more commercial. The effect’s persistence across divergent neighborhoods suggests that it is not simply a function of neighborhood characteristics like land use, sidewalk width, or pedestrian density or demographics.

These findings comport with our pre-registered hypotheses and are consistent with well-established theories of outgroup bias and threat, as well as evidence that young black men in particular are stereotyped as threatening (Cottrell and Neuberg 2005; Harris-Lacewell 2001; Goff et al. 2014). 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 important implications for decision-making (Sands 2017).
Why do our findings seemingly diverge from studies conducted fifty years prior? Why do we find that white pedestrians avoid, rather than invade, the personal space of our confederates, or engaging in dominance behaviors? First, our intervention, measurement strategy, and recorded outcome are distinct from those of prior research examining whether a subject walks between versus around two confederates (i.e., [Knowles](#) 1973; [Brown](#) 1981). Conceptually, the invasion of shared space paradigm differs from our own in that, in the latter, confederates violate social norms by rudely blocking pedestrians’ way. The measured outcome — whether subjects pass through rather than move around the pedestrian dyad — reflects an explicit act of social dominance. Our paradigm, in which confederates comply with the social norm of not obstructing the path of others, creates a more realistic, everyday scenario and allows for detection of more subtle changes in pedestrian behavior, previously undocumented in a systematic scientific fashion. Future studies might probe the scope conditions for avoidance versus invasion; for example, how narrow must the bottleneck be before pedestrians choose to penetrate the black or white dyads? Second, our sample size is much larger than prior studies, helping to ensure internal validity. This is particularly important, as [Brown](#) 1981’s study suffers from imbalance in foot traffic density across treatment conditions, which may confound the relationship between the race of the confederates and dyad penetration.

This study carries important implications. First, we document systematic racial avoidance in the real world, a finding that is highly consistent with the subjective narratives voiced by people of color, for whom stereotype threat ([Steele](#) 2011) and ‘micro-aggressions’ carry pernicious implications ([Sue et al.](#) 2007). Avoidance experienced by black individuals, day in and day out, likely 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. That is, the very public, widespread, and chronic occurrence of pedestrian racial avoidance may have spillover effects that influence others’ behavior in sub-
tle but destructive ways. For example, law enforcement – even if trained to recognize their own implicit biases – may detect bystander behavior and overestimate the level of threat posed by African Americans in ambiguous situations.

Second, we develop a method that allows researchers to study mass pedestrian behavior in the real world, and which 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 (Dietrich, 2015). By combining our measurement strategy with field experiments future scholars can replicate our study in different neighborhoods, and with different confederate characteristics, such as socioeconomic status, gender, ethnicity, and age.
References


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