Policy Research Working Paper 9407

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Jimena Llopis Abella
Anna Fruttero
Emcet O. Taş
Umar Taj

WORLD BANK GROUP
Poverty and Equity Global Practice
&
Social Sustainability and Inclusion Global Practice
September 2020

Policy Research Working Paper 9407

Abstract

Public spaces can be an instrument to increase social cohesion, yet they are often underutilized. This paper presents findings from a randomized virtual reality experiment with more than 2,000 participants in Karachi, Pakistan. The paper investigates the relationship between urban design, willingness to use public spaces, and social cohesion. The findings show that exposure to a two-and-a-half-minute-long virtual reality experience featuring various urban design and social diversity elements has a statistically significant impact. In particular, improvements in the design of a public park through the virtual reality experience increased the park's perceived attractiveness and participants' willingness to use it. Exposure to diverse social groups in the virtual reality experience, by itself, had mixed impacts on social cohesion indicators such as trust and perception of and willingness to interact with outgroups. The impacts varied by ethnic affiliation, income, sex, and education level. This may be partly explained by the segregated nature of Karachi and the high prevalence of mistrust of outgroups. The paper illustrates how modern technology can be used as an effective, low-cost tool for diagnosing social phenomena, soliciting feedback about urban interventions for inclusive design, and promoting social contact.

This paper is a product of the Poverty and Equity Global Practice and the Social Sustainability and Inclusion Global Practice. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at http://www.worldbank.org/prwp. The authors may be contacted at jimenallopis@worldbank.org.

Urban Design, Public Spaces, and Social Cohesion Evidence from a Virtual Reality Experiment[1]

Jimena Llopis Abella, Anna Fruttero, Emcet O. Taş and Umar Taj[2]

Keywords: Virtual Reality, public space, diversity, behavior, Pakistan.

JEL: D9, O1, R0.

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1 Acknowledgments: The authors thank Emily M. Romano, Vanessa Guerra and Berta Zabaleta Caton for excellent research assistance; Jimmy Vainstein and Roxana Bravo Denis for developing the VR experiences; Jon Kher Khaw, Annie Gapihan, Najm-Ul-Sahr Ata-Ullah and Jorge Luis Castaneda Nunez for providing feedback on earlier drafts; Jana El-Horr, Shan Rehman, Rahat Ali and Zuha Moin for technical support; Bilal Gilani, Yasir Herekar, Fatima Amir and other members of Gallup Pakistan and Jump Activations for carrying out the fieldwork; and members of the Mind, Behavior and Development (eMBeD) Unit and the Social Development Global Practice of the World Bank for useful feedback on various aspects of this research. Generous funding from the Global Facility for Disaster Reduction and Recovery (GFDRR) is gratefully acknowledged. All findings, interpretations and errors belong to the authors.

2 The authors are affiliated with World Bank; International Monetary Bank and World Bank; World Bank; and Warwick Business School, respectively. Correspondence: Jimena Llopis Abella (jimenallopis@worldbank.org).

1. Introduction

Social cohesion is an essential foundation of inclusive and sustained development. Over the past 10 years, there have been various forms of social unrest in countries around the world. While the specific events that spurred each of these episodes are unique, the perception of growing economic inequality and the limited scope for participation in decision making have been common themes underlying these movements. Although strong economic management and social expenditure are necessary, they have proven insufficient in contexts where social cohesion is low or deteriorating (OECD 2011). As a result, identifying effective instruments to foster social cohesion remains an essential objective for policy makers across the world.

In urban areas, public spaces are an important aspect of social life and can play a vital role in delivering better economic, health, social, and environmental value for its residents (CABE 2004). Better designed, multi-use, green public spaces can encourage people to walk more, interact with others, and benefit from a natural landscape (Das 2008). Public spaces are also crucial sites for the interplay of social relations among different groups. While urban designers have traditionally pursued instrumental goals in designing cities, such as bringing order to densely populated areas, a fundamental function of public spaces is also to promote informal, spontaneous, non-transactional social interaction among its residents (Stevens 2007). In recent years, more attention has been given to social and cultural factors in developing public spaces. However, there is little empirical documentation of whether, and to what extent, urban design attracts users from diverse backgrounds and facilitates social contact, and whether these interactions promote social cohesion.

This paper presents the result of a Virtual Reality (VR)[3] experiment, conducted with youth in the city of Karachi, Pakistan, in April-May 2019. The experiment aimed to assess the impacts of improvements in the design of a public park and people's exposure to social diversity on their intention to use the public space and their attitudes towards other social groups. Specifically, the study focused on two questions: (i) whether improvements in the physical design of a public park had any impact on participants' willingness to use the park, and on their trust, stereotypes and willingness to interact with other social groups; and

3 While the first form of VR goes back to 1957, the first head mounted display attached to a computer which enabled the user to see a virtual world was created in 1968 (Virtual Reality Society, 2018). Since then, helped by several technological breakthroughs in the last five years that have made VR hardware highly affordable, VR has been developed in an endless list of applications such as the military, arts, and health care.

(ii) whether exposure to individuals from diverse backgrounds in the park changes perceptions against outgroups, i.e. groups that had different sex and ethnicity than themselves.

Early work in behavioral economics focused on developing decision tasks in laboratory settings to verify the validity of the economic rationality hypothesis (Kahneman and Tversky, 1975). However, more recently the debate has shifted to whether findings from laboratory settings can be generalized to the real world, since laboratory settings can sometimes fail to incorporate context (Harrison and List 2004, Levitt and List 2007). People make decisions and choices based on the environments that they find themselves in, which is defined as "ecological rationality" (Gigerenzer and Todd, 1999). This is even more important when studying work related to social cohesion, emotion and empathy because people might only reveal their true preferences when exposed to the right context. The VR technology provides an opportunity to embed ecological context while maintaining a high degree of experimental control (Seinfield et al., 2018). The effectiveness of VR as an empathy tool has been shown in various studies, such as simulating forest fires to investigate how subjects change their propensity to pay for fire prevention policies (Fiore et al., 2009), inducing a full body ownership illusion that allows offenders to be in the body of a victim of domestic abuse and thereby modifying social-perceptual processes (Seinfield et al., 2018), and simulating disasters closer to home and thereby increasing empathy for victims of far-away disasters (Deep Empathy, MIT Media Lab). Additionally, compared to studies that use control conditions (e.g. watching a video, reading or imagining the life of another), VR can produce more attitudinal and behavioral change since it includes movements comparable to the real world.

Karachi's socially diverse setting offered an interesting context for the VR experiment discussed in this paper. Serving as the commercial hub of Pakistan, Karachi is a megacity of 15 million people who belong to different ethnicities. According to the 1998 Census, the latest year for which ethnicity information was available at the city level, 48.5 percent of the city's residents were Urdu speakers (Muhajirs), 13.9 percent were Punjabi speakers (Punjabis), 11.4 percent were Pashto speakers (Pashtuns), 7.2 percent were Sindhi speakers (Sindhis), 4.3 percent were Balochi speakers (Balochs), and the remaining 14.5 percent were categorized as Others (Pakistan Bureau of Statistics, 1998). While many neighborhoods are segregated based on income, the city also has clusters with ethnically homogenous neighborhoods being affected by urban violence emanating from inter-ethnic and political tensions in the recent decades. The relationship between social groups remains difficult and many residents struggle to find adequate mechanisms for their voice and inclusion (World Bank 2017, Breman 2012). Not only does the city have a shortage of public spaces that could facilitate interaction between the city's diverse

population, but the existing ones are often empty, as they are perceived to be unsafe. Thus, the residents of Karachi miss out on the possibility of cultivating social interactions in these public spaces.

The experiment discussed in this paper shows that improved design of public spaces could be an instrument for enhancing their use, thus facilitating social contact and exposure to diversity, as well as helping overcome negative attitudes and perceptions that social groups may hold against each other. Specifically, the findings show that people reacted positively to better designed, multi-use, green spaces in a densely populated megacity, suggesting that better design can help increase the use of public spaces. However, the levels of this positive reaction varied by subgroups, with a lesser impact on vulnerable groups. Exposure to diversity in the VR experiment did not have a clear positive impact on social cohesion and, in some cases, the impact was negative. However, when exposure to diversity was combined with improvements in urban design, the reported willingness to use the park remained positive, suggesting that being exposed to diversity did not outweigh the positive impact of improved urban design. Overall, the experiment shows that VR technology can be an effective diagnostic tool for identifying and addressing behavioral barriers to the use of public spaces, as well as for soliciting feedback on costly urban design alternatives in a fast, cost-efficient way. It also highlights the importance of tailoring urban design to the specific needs of social groups.

The paper is organized as follows. Next section presents a brief overview of the literature. The third section describes the experimental design, data sources and methodology. The fourth section presents the main findings, and the last section concludes with a discussion of the paper's limitations and policy implications.

2. Social Cohesion, Intergroup Exposure, and Public Spaces

The absence of social cohesion is a major challenge for many countries across the world. Although evidence suggests that cohesion, intended as "togetherness in a society", is positively correlated with economic growth, it is a specific type of social cohesion across different groups that matters. Intergroup cohesion, also known as "bridging social capital", has a positive effect on economic growth, whereas membership in clubs and voluntary associations, or "bonding social capital", has a negative relationship. Intergroup cohesion can indicate cooperation among identity-based groups, but membership in clubs and other voluntary associations can reflect "inward-looking behavior", which might explain the conflicting impacts of social cohesion on economic growth (Pervaiz & Chaudhary, 2015). Other studies suggest that

such social capital can provide access to resources in the face of shocks, such as natural disasters, along with psychological support (Aldrich & Meyer, 2014).

There is a rich collection of studies from the social and behavioral sciences literature evaluating the impact of intergroup contact on attitudes and perceptions. A meta-analysis of almost 700 studies showed that greater intergroup contact is associated with lower levels of prejudice against outgroups and its effects typically extend beyond the immediate contact situation (Pettigrew & Tropp, 2006). Similarly, another meta-analysis demonstrated the effectiveness of both direct and indirect intergroup contact programs and found that contact interventions can improve ethnic attitudes in conflict-affected contexts (Lemmer & Wagner, 2015).

In South Asia, the literature focuses predominantly on India, where several studies have examined the impact of intergroup exposure and contact on inter-religious attitudes and cross-caste friendships. Barnhardt (2009) found that, within public housing, increased exposure of Hindus (the majority group) to Muslims (the minority group) increased Hindus' willingness to live with Muslims and improved their explicit attitudes toward Muslims (Barnhardt, 2009). Lowe (2018) found that, within a cricket league, "collaborative contact" across identity groups increased cross-caste friendships, while "adversarial contact" reduced it. Turner & Crisp (2009) found that young (non-Muslim) participants that imagined talking to an elderly (Muslim) stranger showed more positive implicit attitudes towards elderly (Muslim) people. Thus, a greater exposure to outgroups can lead to more positive relations among majority and minority groups in a given context.

While the behavioral literature has explored various ways in which intergroup contact can be formed, the relationship between intergroup exposure (i.e. induced, short-term, casual exposure to people from other social groups, such as those belonging to different ethnicity or gender) and social cohesion remains understudied. Previous studies mainly address intergroup contact, as opposed to intergroup exposure, and do not examine potential impacts on social cohesion indicators such as trust, stereotypes or willingness to cooperate with outgroups. While intergroup exposure may happen naturally without the need of any policy intervention, it does not necessarily imply interaction with outgroups. Intergroup exposure can provide the opportunities or settings for such interaction to occur. According to Wessel (2009), "mere exposure to diversity may reduce prejudice" suggesting that being exposed to outgroups may increase our liking of those groups (Wessel, 2009; Barnhardt, 2009).

Since the 1980s, public spaces have increasingly become a key component of urban regeneration and development schemes (Carmona, 2019). There has been a significant shift towards public spaces

being accessible places developed through inclusive processes. While much has been written on the topic by urban designers and architects, most of this literature consists of theoretical design principles or case studies situating public spaces in the historical context of specific cities (see, for example, Madanipour, 2013). It is generally acknowledged that public spaces are promising sites to promote social interaction and cohesion (Buijs at al., 2010), but to our knowledge, there are no rigorous assessments of whether urban design can foster intergroup exposure by increasing the willingness of citizens from diverse backgrounds to use a public space.

This study makes two contributions to the relatively scant literature on social cohesion, intergroup exposure, and public spaces. First, it sheds some light on the link between urban design and social cohesion, pointing to potential interactions and trade-offs between the two, in the context of a socially diverse megacity. Second, it takes advantage of innovative VR technology to generate empirical evidence on an understudied area, namely the interplay between intergroup exposure and urban design of public spaces. The findings not only have implications for policy makers on building cohesion in socially stratified societies, but also illustrate the value of technology in identifying and addressing behavioral barriers to social interaction.

3. Study Design, Data, and Methodology

This study was conducted in Karachi between April and May 2019. Over 2,000 youth between the ages of 18 and 30 years old[4] were recruited from 21 randomly selected locations across the city to participate in the intervention. The locations for the experiment were selected from 50 localities included in the list of Urban Census Circle, with an average of 96 participants per location. To recruit the participants, data collectors identified target individuals in public places (e.g., colleges, universities, shopping malls, cinemas, parks or theatres), as well as used door-to-door recruiting and provided transportation to a nearby field office for participants to take the experiment.

The sampling method was Probability Proportional to Size (PPS), ensuring that areas with larger population were more heavily represented in the sample. To the extent possible, the sample sought diversity in terms of age, gender and ethnicity. Due to sensitivities about ethnic affiliation, the survey did not capture ethnicity directly, but instead proxied this variable through native language, with the caveat

4 This age group was chosen given the demographic structure of the population of Karachi. The choice of intervention was also motivated by the likelihood that VR would be appealing to this age group.

that there is not always a one-to-one relationship between ethnicity and native language (see discussion below).

3.1. Intervention

Once the participants were selected, they were randomly assigned to one of four groups to watch a 2:34 minutes-long 360-degree VR experience using an Oculus Go VR headset (see Appendix A for still images from the VR experiences or follow the video links provided below for each treatment group). Immediately after watching the videos, each participant was asked to take a brief computer-assisted survey. The four 360-degree VR experiences in the experiment included:

i. Control group: Video of a well-known public park (Burns Garden) in its natural state, with no modifications;

ii. Treatment-1 (urban design): Video with 3D urban design elements added to the park;

iii. Treatment-2 (diversity): Video with a diverse group of park users added to the park;

iv. Treatment-3 (urban design + diversity): Video including both the additional 3D urban design elements and the diverse group of park users.

The control group was shown a video of a well-known public park called Burns Garden in its natural state, while the three treatment videos were enhanced with additional content identified through primary and secondary research. An online survey was carried out on Facebook in Urdu to collect information on people's perceptions about public parks in Karachi.[5] The survey was complemented with an extensive review of the literature on barriers that hinder the use of parks (see Appendix B). The Facebook survey indicated that public parks in Karachi were generally perceived as dull and unsafe places. When asked about the reasons for feeling unsafe, respondents mentioned lack of proper lighting at night, presence of drug users, fear of harassment (especially among women), and parks often being deserted. Respondents indicated that they wanted to see clean and fun parks that include various amenities, such as a library, bookstore, flower market, community garden, and tea kiosk. The characteristics most commonly mentioned in the comments left on the Facebook page included "green", "clean", "water", "trees", and "flowers".

5 The survey was run for a period of five days (February 27 to March 3, 2019), reaching a total of 323,708 Facebook users between the ages 18-26 years. Of these, 7,356 users clicked on the link and only 182 completed the survey in full (100 of whom were men and 82 were women). A tablet was offered as a prize to one randomly selected participant to encourage participation.

Using this information, the park VR experiences for Treatment-1 (T1) and Treatment-3 (T3) were digitally enhanced with the following elements: (i) additional entry/exit to the park; (ii) street lights; (iii) tea kiosk; (iv) emergency phone; (v) group tables and benches; (vi) signals promoting respect of others; (vii) picnic area for families; (viii) removal of trash; (ix) garbage bins; (x) shady trees and tall grass; (xi) play fixtures for children; and (xii) greener grass.[6]

To add social diversity to the park for Treatment-2 (T2) and Treatment-3 (T3), 22 actors were hired to populate the park in the VR experience. The actors differed in sex (men and women), age (children, young adults and older adults) and ethnicity (Sindhi, Pashto and Muhajir). They were shown walking around and interacting with each other. Although the actors did not speak, their physical characteristics and clothes matched the visual traits of various ethnic groups in Karachi.[7] These characteristics were well-noticed by those who participated in the VR experience: 93 percent of those who were exposed to the diversity treatments (T2 or T3) reported seeing men; 92 percent reported seeing women; 73 percent reported seeing Sindhis; 72 percent reported seeing Pashtuns; and 84 percent reported seeing Muhajirs.

3.2. Data

The data used in this study were collected through a computer-assisted survey conducted right after the participants were exposed to the VR intervention. The survey included questions about the park and the people seen in the VR experience, as well as demographic information about the participants.

In total, 2,010 respondents participated in the study by experiencing one of the four VR interventions and completing the follow-up survey. However, during data analysis, it became clear that some participants may have been too hasty to respond to the survey, whereas others took an anomalously long time in their response time. The sample was trimmed to exclude respondents whose response duration was below the 1st percentile (3.12 minutes) and above the 99th percentile (29.35 minutes) to mitigate potential biases that may emanate from the responses of these individuals (see Appendix C for summary statistics). In addition, a few observations were dropped to ensure that the working sample had

6 The enhancements were constrained by the available 360-degree VR technology, as well as by the park's natural layout and the angle of the three-dimensional video recording.

7 For example, Pashtun actors wore a traditional hat; Sindhi actors wore a traditional scarf; and Muhajir actors wore more casual, less traditional clothes.

a consistent number of observations across estimates.[8] The resulting sample consisted of 1,924 respondents.

The sample includes individuals between the ages of 18-30, who lived in Karachi at the time of data collection. It is balanced in terms of gender (54 percent men, 46 percent women), but the age distribution is concentrated at the tails.[9] Approximately 16 percent of respondents were 18 years-old and 19 percent were 30 years-old, whereas other ages (19 to 29 years) each represented only 4-8 percent of the sample. The respondents were more educated than the national average. While the primary net enrollment rate in Pakistan is 67.7 percent and the secondary enrollment rate is 38.5 percent,[10] 100 percent of the sample reported having completed primary and 87.5 percent reported having completed secondary school (further, within the latter, 31 percent had a bachelor's and almost 6 percent had a master's degree). Approximately 33 percent of the respondents reported working, another 29 percent reported studying, and 15 percent reported doing both. Most respondents had a lower monthly household income (less than 30,000 Pakistani rupees) compared to the national average (35,662 Pakistani rupees or approximately US$230).[11]

Given the sensitivities about asking participants to disclose their ethnic background, the study participants were asked about their "native language" instead of ethnicity. This was then treated as a proxy for ethnic affiliation. As a result, ethnic diversity in the sample might be underreported, especially if some respondents were unsure about the survey's emphasis on "native language" and mistakenly reported a language they knew how to speak. Further, it is possible for younger individuals living in a cosmopolitan urban setting such as Karachi not to speak the native language associated with their ethnic identity. The literature also suggests that individuals might choose to misrepresent their identity, consciously or subconsciously, for security concerns, politics, social identity, self-understanding or other reasons (see discussion in Taş et al., 2014). With these caveats in mind, most respondents in the sample, 77 percent, reported Urdu as their native language, and thus were assigned to the Muhajir ethnic group.

8 At the beginning of the survey, some questions were not coded as compulsory and thus, some participants did not complete all the survey questions. These observations were later dropped to maintain consistency across the samples used for the analysis.

9 Age was self-reported, and the facilitators did not check identity cards. It is possible for the sample age range to be wider than 18-30 years if the clustering of respondents at the two tails is caused by those younger than 18-years-old overstating their age and those older than 30-years-old understating their age to participate in the study.

10 World Development Indicators (WDI), World Bank, 2018.

11 Household Integrated Economic Survey (HIES) 2015-16.

The randomization process ensured that ethnicity and other demographic characteristics, as well as the frequency with which the participants reported visiting parks, were balanced across the treatment groups (see Appendix D). In interpreting the results of the survey, it should be borne in mind that ethnic identity was measured imperfectly.

3.3. Methodology

Two hypotheses are tested in this study. The first is that improving the layout of public spaces will increase the respondents' willingness to use it (T1-Urban Design). The second is that increasing the respondents' exposure to diverse social groups in public spaces will increase their willingness to use the space as well as their attitudes regarding outgroups (T2-Diversity). The following model is used for assessing the individual effects (T1 and T2) and the joint effect (T3-Urban Design & Diversity) of the intervention:

$$Y_i = \beta_0 + \beta_1 Urban\ Design_i + \beta_2 Diversity_i + \beta_3 Urban\ Design\ \&\ Diversity_i + X_i'\alpha + \varepsilon_i \quad (1)$$

where i denotes respondents; Y_i refers to the dependent variables of interest (described below); $Urban\ Design_i$, $Diversity_i$, and $Urban\ Design\ \&\ Diversity_i$ refers to the VR experienced by the respondent i and take on a value of 1 for participants in T1, T2 or T3, respectively (0 otherwise); and X_i denotes a vector of participant covariates.[12,13] ε_i represents the error term.

The outcome variables include four indices that measure the respondents' willingness to use public spaces (index for "use of public spaces") and their relationship with outgroups, loosely referred to in this paper as social cohesion (indices for "trust toward outgroups", "perceptions toward outgroups", and "willingness to interact with outgroups"). While the respondents' willingness to use public spaces is relatively easy to measure, there is no standard way across the literature to measure social cohesion. In this paper, social cohesion is captured through the three indices mentioned above. In all these indices, "outgroups" refer to individuals from a different ethnicity and the opposite sex. For the third component

12 The control variables include the respondent's age (log), sex, monthly household income above/below median , education level above/below median, frequency of park use, native language (Urdu vs non-Urdu speakers) whether or not the VR/survey was taken during Ramadan, whether or not the participant reported having participated in a community activity with outgroups in the past year, and fixed effects of current status (studies, works, studies and works, or does neither), VR/survey facilitator and location.

13 If $\beta_1 > 0$, improving the layout of public spaces has a positive impact (negative otherwise); if $\beta_2 > 0$, exposure to diverse groups has a positive impact (negative otherwise); and if $\beta_3 > 0$ then the two interventions jointly have a positive impact on the outcome variables (negative otherwise).

of the social cohesion index (i.e. "willingness to interact with outgroups"), participants were asked to imagine that they need to become part of a committee to decide what type of amenities should be provided in the park that they saw in the VR experience. They were then told that in this committee they would be working with one other person, who was always shown to be a member of the opposite sex and of a randomly assigned ethnic group. The selection of the social cohesion indicators was informed by Naef and Schupp (2009), Wilson (2017), and Glaeser, et. al. (2000) for the measures of trust; Strangor (2012) on stereotypes and prejudice; and UNICEF's Compilation of Tools for Measuring Social Cohesion, Resilience, and Peacebuilding on inclusion and tolerance. They were relevant for the study context, where other data sources had shown that perceptions and trust toward other groups were low—according to the 2018 World Values Survey, nearly 70 percent of the Pakistanis mistrust people of another religion and 74 percent believe that most people cannot be trusted.

The variable definitions are provided in Table 1.[14] Because the survey included a wide set of questions, four indices were constructed to reduce the dimensionality of the data and the number of statistical tests performed:

$$I_i = \sum_m z_{im} \tag{2}$$

where I_i refers to the index score for each individual i, defined as the sum of the z-scores z_{im} of the variable m included in the index. The control mean and standard deviation were used to construct the z-scores. Additionally, I_i was standardized for ease of interpretation. Cronbach's Alpha, which shows the strength of the consistency of the components included in each index, indicates that three of the indices ("use of public spaces", "trust toward outgroups" and "perceptions toward outgroups") have a coefficient higher than 0.6, while one index ("willingness to interact with outgroups") has a coefficient of 0.51, just above the threshold.

Table 1. Variable Definitions

14 For all questions, "positive" responses were grouped and assigned a value of 1, whereas all "negative" and "neutral" responses listed below were grouped and assigned a value of 0. The positive responses included: "I somewhat like it and I like it a lot", "Likely and Extremely likely", "Agree and Agree strongly", "Trust somewhat and Trust completely", and "Relaxed and Happy". The negative or neutral responses included: "I didn't like it at all, I somewhat didn't like it, and Neutral", "Extremely unlikely, Unlikely, and Neutral/Indifferent", "Disagree strongly, Disagree, and Neither agree nor disagree", "Do not trust at all, Do not trust much, and Neither trust nor distrust", "Angry, Tense, and Indifferent".

Outcomes	*Indices*	*Components*
Willingness to use public spaces	Use of public spaces	- Rate how much you liked the park you just saw in the VR experience (1= somewhat or a lot) - How likely are you to go back and visit the park during your free time? (1=likely or extremely likely)
Social cohesion	Trust toward outgroups	- Think about the different groups of people who live in Karachi. How much do you trust people of another ethnicity than yours? (1= somewhat or completely) - How much do you trust people from the opposite sex? (1= somewhat or completely)
	Perceptions toward outgroups	- Thinking about someone from a different ethnicity makes me feel… (1= relaxed or happy) - Thinking about someone from the opposite sex makes me feel… (1= relaxed or happy)
	Willingness to interact with outgroups	- I would like to have more friends of a different ethnicity (1= strongly agree or agree) - I would like to have more friends of a different ethnicity, but I don't have the opportunity (1= strongly agree or agree) - Imagine that you need to become part of a committee to decide what type of amenities should be provided in the park. How likely would you be to form team with [person from the outgroup] and participate in the committee? (1= strongly agree or agree) *

Note: Responses to the survey questions were ranked on a 5-response Likert scale.

Before discussing the findings, it is important to note a few caveats about the intervention and the methodology. The objective of this study was to assess perceptions of the respondents, as opposed to their actions. Therefore, all outcome variables captured self-reported responses, which may or may not reflect actual behavior. It would have been difficult to measure behaviors directly in a VR setting, especially given that the VR experience lasted only 2:34 minutes. In addition, the length of the intervention may have been too short to induce change. The study also tried to capture hard-to-measure indicators, such as ethnic identity and social cohesion outcomes, which may have been misunderstood by the participants or measured with error. It is possible also that the responses were subject to status quo bias (tendency to choose pre-set options even when many other options are available), unconscious bias (attitudes or stereotypes that affect our understanding, decisions or actions in an unconscious way) or social desirability or response bias (tendency to answer in a manner that is socially acceptable). To assess the degree of bias in the responses, a placebo question was posed to the participants of the two treatment groups that included diverse social groups , asking if they saw someone walking their dog in the experiment (there was no such case in the VR experience). Although nearly 30 percent of respondents

said that they saw someone walking their dog, the responses were not significantly different across treatment groups. This increases confidence that if any biases were present, randomization would have ensured that they were present across the various treatment arms, and thus any observed changes can be attributed to the intervention.

4. Findings

The aim of the experiment was to assess whether young people from diverse backgrounds would react positively to improved design of public spaces; whether they would react differently to the presence of diverse social groups in public spaces; and whether exposure to diversity leads to improved social interaction and reduces the negative perceptions that groups may hold against each other.

This section discusses the results of the experiment by presenting the z-scores for the variables of interest in Equation (1), both with and without the covariates, for each of the four outcome variables in Table 1.[15] For ease of interpretation, Ordinary Least Squares (OLS) estimates of a linear probability model are reported, with robust standard errors.[16] In addition to the indices constructed by Equation (2), the individual components that make up the indices are presented. Finally, results for various subgroups are discussed to highlight the differential effects of the intervention by education and income (above and below median), by ethnic affiliation (Urdu versus non-Urdu speakers), and by sex (males versus females). Because subgroup analysis was not planned in advance, random assignment to the treatment groups was not stratified by subgroups (this would have resulted in more robust estimates). Yet, as discussed earlier, demographic and other characteristics are balanced across the treatment groups (see Appendix D).

4.1. Willingness to Use Public Spaces

The results show that improving the physical characteristics of the public space is associated with an increase in the participants' attraction to the park and their willingness to use it. Table 2 reports the effects of the three interventions on the "use of public spaces index" and its components. In particular, exposure to urban design elements is associated with a sizable increase of 0.32 standard deviation on the

15 Along the analysis two models are computed; the first one includes VR/survey location fixed effects only and the second one includes all covariates presented in this section.

16 Results do not differ qualitatively from the estimations using ordered probit.

"use of public spaces" index (p-value<0.01). Columns 3-6 show that this effect is due to an increase in both of the components included in this index.

The impact on the willingness to use public spaces remains positive even when the urban design elements are complemented with social diversity, with an increase of 0.34 standard deviation on the index (p-value<0.01). Although the effect is slightly larger for T3, the F-test confirms that treatment arms T1 and T3 are not statistically different from each other. To help interpret the magnitude of the effect, it is helpful to note that 70 percent of the control group, on average, said they liked and wanted to come back to the park, whereas those exposed to T1 and T3 increased their likeness and willingness to come back by 9 to 13 percentage points. On the other hand, social diversity intervention has no statistically significant impact on the respondents' willingness to use the public space, except for a small positive (although statistically insignificant) impact on the respondents' reported attraction to the park.

Table 2. Treatment Effects on Willingness to Use Public Spaces

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Index Public Space (z-score)		Like Park (=1)		Return Park (=1)	
[T1] Urban Design	0.32***	0.32***	0.13***	0.13***	0.09***	0.09***
	(0.059)	(0.056)	(0.027)	(0.026)	(0.027)	(0.027)
[T2] Diversity	0.03	0.04	0.04	0.04	0.02	0.02
	(0.061)	(0.060)	(0.028)	(0.028)	(0.028)	(0.028)
[T3] Urban Design + Diversity	0.34***	0.34***	0.13***	0.13***	0.10***	0.10***
	(0.057)	(0.055)	(0.026)	(0.026)	(0.027)	(0.026)
Observations	1,924	1,924	1,924	1,924	1,924	1,924
Control Mean	0.00	0.00	0.69	0.69	0.70	0.70
Control Mean (No z-score)	0.70	0.70				
F-test T1=T2 (p-value)	0.00	0.00	0.00	0.00	0.01	0.00
F-test T1=T3 (p-value)	0.63	0.76	0.75	0.87	0.54	0.69
F-test T2=T3 (p-value)	0.00	0.00	0.00	0.00	0.00	0.00
Selected Controls		X		X		X

Notes: Specifications in odd-numbered columns include experiment location fixed effects while even-numbered columns include all the covariates selected. Robust standard errors are shown in parentheses. ***p<0.01 **p<0.05 *p<0.1.

While the overall impacts of T1 and T3 are large and positive, there is heterogeneity in the effects of the intervention on different subgroups. The interventions resulted in a lower willingness to use public spaces among youth in vulnerable groups, namely, those with lower education, lower income, and non-Urdu speakers. There are, however, no statistically significant differences between males and females in terms of the interventions' effect on the use of public spaces. Table 2.A reports the effect of the

intervention by education, income and ethnic affiliation. Column 1 shows that participants with education above the median (completed bachelor's and master) that were exposed to T3 experienced an increase of 0.55 standard deviation on their "use of public spaces index". On the other hand, as shown in Column 2, the same intervention resulted in an increase of only 0.23 standard deviation for those with below-median education levels (completed primary and secondary). This difference is statistically different at the 5 percent confidence level.

Table 2.A. Subgroup Analysis: Willingness to Use Public Spaces (by education, income and ethnicity)

VARIABLES Index Public Space (z-score)	(1) Education above median	(2) Education below median	(3) F-test (p-value) (1)-(2)	(4) Income above median	(5) Income below median	(6) F-test (p-value) (4)-(5)	(7) Urdu Speakers	(8) Non-Urdu Speakers	(9) F-test (p-value) (7)-(8)
[T1] Urban Design	0.41***	0.27***	0.23	0.47***	0.19**	0.01	0.34***	0.27**	0.60
	(0.100)	(0.067)		(0.085)	(0.075)		(0.066)	(0.112)	
[T2] Diversity	0.01	0.07	0.63	0.01	0.07	0.62	0.05	-0.02	0.54
	(0.109)	(0.070)		(0.089)	(0.079)		(0.071)	(0.108)	
[T3] Urban Design + Diversity	0.55***	0.23***	0.01	0.43***	0.24***	0.10	0.41***	0.10	0.01
	(0.097)	(0.069)		(0.084)	(0.075)		(0.064)	(0.111)	
Observations	718	1,206		908	1,016		1,473	451	
Control Mean	-0.16	0.09		-0.13	0.13		-0.03	0.10	
Selected Controls	X	X		X	X		X	X	

Notes: Robust standard errors are shown in parentheses. ***p<0.01 **p<0.05 *p<0.1.

Similarly, Columns 4-5 show that exposure to urban design elements generates an increase of 0.47 standard deviation for the richer participants (monthly household income above the median of 30,000 Pakistani rupees) and 0.19 for the poorer. This difference is statistically different at 5 percent confidence level. Finally, Columns 7-8 show that exposure to urban design elements and diversity is associated with an increase of 0.41 standard deviation on the "use of public spaces index" for Urdu speakers, but this finding does not hold for non-Urdu speakers. This difference is statistically different at 5 percent. In other words, even though the different social groups expressed that they like the improved public space and want to come back after having experienced the T1 and T3 interventions, there are group-based differences in the magnitude of these impacts. This raises an important question regarding inclusive urban design for vulnerable groups, which is discussed at the end of the paper.

4.2 Social Cohesion

Compared to the use of public spaces, the impacts on social cohesion are mixed. The impacts on trust toward outgroups, perceptions toward outgroups, and willingness to interact with outgroups are summarized in Tables 3-5, respectively, both for the full sample as well as for selected subgroups.

First, Table 3 reports that the intervention did not have a statistically significant effect on the "trust toward outgroups index" (Column 1-2) and its components, i.e. trust toward different ethnic groups and the opposite sex (Columns 3-4 and 5-6, respectively). The only exception is the urban design and diversity intervention, which had a negative impact of 0.06 standard deviation on trust toward people from the opposite sex (Columns 5 and 6). The F-tests indicate that the treatment arms are not statistically different from each other.

Table 3. Treatment Effects on Trust Toward Outgroups

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Index Trust Outgroups (z-score)		Trust Different Ethnic Group (=1)		Trust Opposite Gender (=1)	
[T1] Urban Design	-0.07	-0.06	0.00	0.01	-0.04	-0.04
	(0.064)	(0.063)	(0.032)	(0.032)	(0.032)	(0.032)
[T2] Diversity	-0.06	-0.06	0.02	0.02	-0.05	-0.04
	(0.063)	(0.063)	(0.032)	(0.032)	(0.032)	(0.032)
[T3] Urban Design + Diversity	-0.03	-0.05	0.01	0.01	-0.06*	-0.06**
	(0.061)	(0.060)	(0.031)	(0.031)	(0.031)	(0.031)
Observations	1,924	1,924	1,924	1,924	1,924	1,924
Control Mean	0.00	0.00	0.60	0.60	0.49	0.49
Control Mean (No z-score)	0.55	0.55				
F-test T1=T2 (p-value)	0.90	0.91	0.54	0.59	0.90	0.89
F-test T1=T3 (p-value)	0.54	0.81	0.69	0.80	0.63	0.37
F-test T2=T3 (p-value)	0.63	0.91	0.82	0.77	0.72	0.45
Selected Controls		X		X		X

Notes: Specifications in odd-numbered columns include experiment location fixed effects while even-numbered columns include all the covariates selected. Robust standard errors are shown in parentheses. ***p<0.01 **p<0.05 *p<0.1.

There is, on the other hand, significant heterogeneity in the impacts observed on different subgroups. T1 and T3 resulted in lower trust among the most vulnerable groups, including women and those with lower incomes, whereas T2 had no statistically significant impact. Columns 1-2 in Table 3.A shows that exposure to urban design elements is associated with a decrease of 0.18 standard deviation in the "trust toward outgroups index" among those with monthly incomes below the median and the difference is statistically different at 5 percent. Similarly, Columns 4-5 show that exposure to urban design

and diversity is associated with a decrease of 0.16 standard deviation on trust among young women and this difference is statistically different at 10 percent.

Table 3.A. Subgroup Analysis: Trust Toward Outgroups (by income and sex)

VARIABLES Index Trust Outgroups (z-score)	(1) Income above median	(2) Income below median	(3) F-test (p-value) (1)-(2)	(4) Male	(5) Female	(6) F-test (p-value) (4)-(5)
[T1] Urban Design	0.08	-0.18**	0.04	-0.04	-0.05	0.92
	(0.088)	(0.090)		(0.084)	(0.095)	
[T2] Diversity	-0.01	-0.08	0.58	-0.03	-0.05	0.90
	(0.090)	(0.090)		(0.085)	(0.093)	
[T3] Urban Design + Diversity	0.06	-0.13	0.10	0.05	-0.16*	0.08
	(0.085)	(0.085)		(0.079)	(0.091)	
Observations	908	1,016		1,034	890	
Control Mean	-0.03	0.03		0.15	-0.18	
Selected Controls	X	X		X	X	

Notes: Robust standard errors are shown in parentheses. ***p<0.01 **p<0.05 *p<0.1

Second, Table 4 shows the effects of the intervention on the "perceptions toward outgroups index" and its components, measuring how happy and relaxed the respondents felt when thinking about outgroups. Again, none of the treatment arms has any effect on the index, but there is a statistically significant impact on perceptions toward the opposite sex at the indicator level. Specifically, exposure to diverse social groups in the VR experience is estimated to cause between 0.07 and a 0.08 percentage points reduction in the respondent's perceptions toward the opposite sex (Columns 5-6), meaning that young women felt less relaxed or happy when thinking about the men they saw in the public space.

When looking at the subgroups, the only statistically significant results pertain to Urdu and non-Urdu speakers, taken as a proxy for Muhajir ethnic group versus other ethnicities. Table 4.A reports the effect of the intervention on "perceptions toward outgroups index" by ethnic affiliation. Exposure to urban design elements is associated with an increase of 0.31 standard deviation on the "perceptions toward outgroups index" among non-Urdu speakers. The difference between Urdu and non-Urdu is statistically different (p-value<0.01), suggesting that non-Urdu speakers report positive perceptions toward other ethnic groups, i.e. Urdu speakers, as well as toward the opposite sex, when they experience improved urban elements in the VR. It is interesting that the differences do not hold when the intervention introduces diversity in T2 and T3, suggesting that the positive impact of the urban design intervention

fades away when diverse social groups are introduced. However, since non-Urdu speakers constitute a relatively small share of the sample, some covariates were imbalanced at conventional significance levels and therefore the results for non-Urdu speakers should be interpreted with caution.[17]

Table 4. Treatment Effects on Perceptions Toward Outgroups

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Index Stereotypes (z-score)		Ethnicity (=1)		Sex (=1)	
[T1] Urban Design	-0.02	-0.00	-0.01	-0.00	-0.02	-0.01
	(0.057)	(0.054)	(0.028)	(0.027)	(0.029)	(0.029)
[T2] Diversity	-0.07	-0.05	-0.02	-0.01	-0.08***	-0.07***
	(0.058)	(0.055)	(0.028)	(0.027)	(0.029)	(0.028)
[T3] Urban Design + Diversity	-0.05	-0.06	-0.02	-0.03	-0.04	-0.05
	(0.058)	(0.055)	(0.028)	(0.027)	(0.029)	(0.028)
Observations	1,924	1,924	1,924	1,924	1,924	1,924
Control Mean	0.00	0.00	0.31	0.31	0.38	0.38
Control Mean (No z-score)	0.35	0.35				
F-test T1=T2 (p-value)	0.41	0.30	0.78	0.67	0.04	0.03
F-test T1=T3 (p-value)	0.63	0.22	0.70	0.30	0.47	0.24
F-test T2=T3 (p-value)	0.74	0.86	0.92	0.54	0.17	0.31
Selected Controls		X		X		X

Notes: Specifications in odd-numbered columns include experiment location fixed effects while even-numbered columns include all the covariates selected. Robust standard errors are shown in parentheses. ***p<0.01 **p<0.05 *p<0.1.

Table 4.A. Subgroup Analysis: Perceptions Toward Outgroups (by ethnicity)

VARIABLES Index Stereotypes (z-score)	(1) Urdu Speakers	(2) Non- Urdu Speakers	(3) F-test (p-value) (1)-(2)
[T1] Urban Design	-0.08	0.31***	0.00
	(0.063)	(0.112)	
[T2] Diversity	-0.09	0.07	0.23
	(0.064)	(0.118)	
[T3] Urban Design + Diversity	-0.06	-0.07	0.97
	(0.064)	(0.121)	
Observations	1,473	451	
Control Mean	-0.02	0.07	
Selected Controls	X	X	

Notes: Robust standard errors are shown in parentheses. ***p<0.01 **p<0.05 *p<0.1.

17 Tables available upon request. For non-Urdu, five of the 33 covariates were imbalanced at conventional significant levels, including age, studying/working status and if participant had worked with outgroups on projects.

Third, Table 5 shows the effects of the intervention on the "willingness to interact with outgroups index" and its components. Results indicate that exposure to urban design elements only leads to an increase of 0.10 standard deviation on the willingness to interact with outgroups index at the 10 percent level. Surprisingly, exposure to diversity has a positive and statistically significant effect of 0.05 to 0.06 percentage points on the likelihood of forming a committee with a member of the opposite sex of any ethnicity (Columns 7-8). This finding somewhat contradicts the negative effects identified earlier on indicators for trust and perceptions toward outgroups. However, it may suggest that exposure to diversity can still promote cooperation among social groups, even when people continue to hold unfavorable perceptions about other groups.

The impact of the intervention on the "willingness to interact with outgroups index" varied by income, but not by any other characteristic. As shown in Table 5.A, for respondents with a monthly household income above the median, exposure to urban design elements, T1, is associated with an increase of 0.23 standard deviation on willingness to interact with outgroups. The effect is similar in size and sign for T2 and these differences are statistically different at the 10 percent level. This suggests that urban design and diversity can promote social interaction, but only for those with higher incomes.

Table 5. Treatment Effects on Willingness to Interact

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Index Interact (z-score)		Friends Diff. Ethnicity (=1)		Friends Diff. Ethnicity, but can't (=1)		Form Team w/ Outgroups (=1)	
[T1] Urban Design	0.09	0.10*	-0.00	0.00	-0.00	0.00	0.04	0.04
	(0.061)	(0.060)	(0.031)	(0.031)	(0.031)	(0.031)	(0.028)	(0.028)
[T2] Diversity	0.08	0.09	0.02	0.02	-0.01	-0.01	0.05*	0.06**
	(0.064)	(0.064)	(0.031)	(0.031)	(0.032)	(0.032)	(0.028)	(0.028)
[T3] Urban Design + Diversity	0.06	0.06	0.01	0.01	0.00	0.01	-0.01	-0.01
	(0.061)	(0.060)	(0.031)	(0.031)	(0.031)	(0.031)	(0.029)	(0.029)
Observations	1,924	1,924	1,924	1,924	1,924	1,924	1,924	1,924
Control Mean	0.00	0.00	0.59	0.59	0.45	0.45	0.72	0.72
Control Mean (No z-score)	0.59	0.59						
F-test T1=T2 (p-value)	0.88	0.81	0.57	0.55	0.75	0.67	0.49	0.51
F-test T1=T3 (p-value)	0.65	0.43	0.67	0.78	0.86	0.83	0.14	0.07
F-test T2=T3 (p-value)	0.78	0.62	0.89	0.74	0.62	0.53	0.03	0.01
Selected Controls		X		X		X		X

Notes: Specifications in odd-numbered columns include experiment location fixed effects while even-numbered columns include all the covariates selected. Robust standard errors are shown in parentheses. ***p<0.01 **p<0.05 *p<0.1.

Table 5.A. Subgroup Analysis: Willingness to Interact with Outgroups (by income)

VARIABLES Index Interact (z-score)	(1) Income above median	(2) Income below median	(3) F-test (p-value) (1)-(2)
[T1] Urban Design	0.23***	0.00	0.05
	(0.087)	(0.082)	
[T2] Diversity	0.20**	-0.03	0.07
	(0.087)	(0.093)	
[T3] Urban Design + Diversity	0.06	0.05	0.93
	(0.085)	(0.086)	
Observations	908	1,016	
Control Mean	0.00	0.00	
Selected Controls	X	X	

Notes: Robust standard errors are shown in parentheses. ***p<0.01 **p<0.05 *p<0.1.

A potential explanation for the mixed impact of the VR interventions on social cohesion outcomes could be that social diversity, as experienced in the VR experiment, has failed to trigger the intended effect on the respondents (especially those who belong to vulnerable groups). In particular, exposure to social diversity may have made some participants feel more inward-looking and connected to their own identity, as opposed to making them feel more open and embracing of other ethnic groups as intended by the experiment. This, in turn, may have partly resulted in the mixed social cohesion results discussed above.

The "social identity theory" (Tajfel and Turner, 1979) posits that people strive to achieve positive self-concept through their belonging to certain group memberships, including multiple and overlapping identities (for example, gender, occupation, religion or ethnicity). When group membership is salient, there might be a heightened sense of identity through the "minority spotlight effect" as described by Crosby et al. (2014), in which people of color can feel uncomfortable about being singled out. The literature on "stereotype threat", similarly, provides empirical evidence on how apparently simple questions on gender, ethnicity or age can induce emotions related to identity (for example, see O'Brien and Crandall, 2003 on gender; Steele and Aronson, 1995 on ethnicity; Lamont, Swift, & Abrams, 2015 on age). These factors may have played a mediating role in the participants' responses on trust toward outgroups, perceptions toward outgroups, and willingness to interact with outgroups

In anticipation of this possibility, the survey included a psychologically reliable measure called the "oneness scale" (Gächter et al., 2015) to examine the effect of exposure to diversity on the subjective closeness of the participants' social relationships. One of the survey questions asked respondents to rate their "connectedness" on a scale from 1 to 5 to a variety of groups, including men and women, as well as

the Urdu-speaking, Sindhi-speaking, and Pashto-speaking communities in Karachi. Table 6 reports the effects of the intervention on the respondents' connectedness to their own ethnicity and other ethnicities.

The oneness scores show that none of the interventions had any effect on the participants' connectedness to a different ethnicity (Columns 1-2), but exposure to diversity increased the participants' connectedness to their own ethnicity by 0.13 standard deviation. The effect under this treatment remains intact and of similar magnitude when urban design elements are added to the social diversity intervention under the treatment of urban design coupled with exposure to diversity. Results for the F-test indicate that the two treatments are not significantly different from each other. This suggests that the survey questions that probed the participants' salient social characteristics may have highlighted their own group identity and offered a motivation for them to maintain their positive self-concept about being part of their own social group.

Table 6. Treatment Effects on Connectedness to Other/Own Ethnicity

	(1)	(2)	(3)	(4)
VARIABLES	Connectedness to other ethnicity (z-score)		Connectedness to own ethnicity (z-score)	
[T1] Urban Design	-0.03	-0.01	0.06	0.08
	(0.069)	(0.067)	(0.066)	(0.066)
[T2] Diversity	-0.05	-0.02	0.11	0.13*
	(0.068)	(0.067)	(0.068)	(0.068)
[T3] Urban Design + Diversity	-0.01	0.00	0.11*	0.13*
	(0.066)	(0.064)	(0.066)	(0.065)
Observations	1,631	1,631	1,631	1,631
Control Mean	0.00	0.00	0.00	0.00
F-test T1=T2 (p-value)	0.85	0.91	0.43	0.46
F-test T1=T3 (p-value)	0.77	0.81	0.36	0.43
F-test T2=T3 (p-value)	0.63	0.72	0.93	1.00
Selected Controls		X		X

Notes: The outcome in the columns 1-2 is the standardized variable created to indicate connectedness to other ethnicities. In columns 3-4 is the is the standardized variable created to indicate connectedness to own ethnicity. Robust standard errors are shown in parentheses. ***p<0.01 **p<0.05 *p<0.1.

5. Conclusion

This study used four short VR experiences to investigate whether improvements in urban design elements of a public park would increase willingness to use it, whether exposure to diversity would improve social cohesion, and how the two would interact. The results unequivocally suggest that

improved urban design can influence young people's decision to visit a public park, even when the improved design is accompanied with exposure to diverse social groups. The fact that such a short (two-and-a-half-minute-long) intervention had a significant impact on self-reported outcomes is remarkable. However, improved urban design does not lead to social cohesion. Further, exposure to diversity does not increase the willingness to use public spaces, nor does it have a consistently positive or negative effect on social cohesion. In fact, all three interventions are not only ineffective for social cohesion, but sometimes can worsen it by lowering trust and perceptions toward outgroups. Even though the impacts on social cohesion were mixed, to our knowledge, this is the first study that systematically exposed people to diversity through VR and monitored its effect on social cohesion measures, providing a foundation for future studies in this area.

These findings have several implications for urban designers and those working on policies to promote social exposure and cohesion in diverse societies. The paper shows robust results indicating that young people react positively to better designed, multi-use, green public spaces**,** suggesting that improved urban design can help increase the use of public spaces and facilitate greater social exposure. However, the willingness to use public spaces is weaker for youth from disadvantaged or vulnerable backgrounds. A potential explanation for this result might be that the less educated, poorer and underrepresented (non-Urdu speaking) ethnic groups did not identify with the changes made in the urban design or found them insufficient to meet their specific needs. The appeal and inclusivity of public spaces need to be considered carefully in order to signal to the vulnerable groups that these spaces also belong to them. While it is encouraging that no gender-differentiated impacts were identified in this paper regarding the use of public spaces—especially in a context where restrictive gender norms and concerns about women's safety would have been expected to result in lower impacts for women—urban designers need to consider the intersectionality of social identities in making public spaces inclusive for everyone.

While progress has been made in making places more accessible to people with different abilities, a similar effort may be required to promote the inclusion of people from different socioeconomic and ethnic backgrounds. When city administrations fail to accommodate a variety of uses and users in the design of their public spaces, they may be hindering the cultural value of their cities and social cohesion among its residents. The design of public spaces could, for example, democratize the "right to space" by consciously curating the look and feel of the space, such as using soft boundaries versus hard boundaries or adding delicate versus durable objects. One way to achieve this can be through deliberative engagement methods, where planners co-create designs with vulnerable groups at the planning stage

(Carcasson, 2016). The results of the experiment discussed in this paper also illustrate that digital technology in general, and VR in particular, can be used as a tool for inclusion and stakeholder engagement in a fast and cost-effective manner. Physical spaces should facilitate civic engagement and civic interaction. VR technology creates opportunities for simulating a close-to reality setting of infrastructure projects, at a low cost and in a short timeframe, before large investments are made on the ground. This can enable urban designers to adopt "tactical urbanism" without having to build or tear down actual physical investments. Further, the approach has the potential to be quickly deployed in other cities and regions. With VR, city administrators can develop a suite of options for a transformational investment, test out ideas, seek input from diverse groups, and quickly adjust virtual designs. This is a more efficient process than the traditional options of using detailed architectural drawings for public consultations. For better data collection and monitoring and evaluation during implementation, VR can also be combined with complementary technologies including drones, aerial photography, satellite mapping, cellphone geofencing, and social media big data mining tools and trends.

This paper found that the effects of increased exposure to diverse groups on trust and perceptions toward outgroups, and willingness to interact with outgroups, are mixed. While these findings are inconclusive, the variations in participants' responses as a result of a short VR intervention nevertheless demonstrate the potential of VR as a stimulus tool to promote social exposure as a first step toward addressing social biases. Further, negative effects of exposure for some groups indicates that exposure to diversity might not be enough, and that future research needs to be conducted. This study thus serves as a test case to showcase a technology-based method of studying social cohesion.

Future research on this topic can expand the post-VR activity beyond a computer-assisted survey. One suggestion is to include an observable and measurable behavior as part of the study, as opposed to only focusing on self-reported survey responses. An example can be to ask people to donate time to help clean a park and measure attendance rates and the time spent, or to ask people to donate money to local organizations known for supporting diverse ethnic groups. Similarly, as the VR technology advances, it may be possible to embed opportunities for behavioral response and interaction within the VR experience itself. Finally, the measures used in this study primed participants directly about ethnic and gender diversity (for example, asking participants whether they spotted men or women or a Muhajir or a Sindhi), which might have induced a response bias. Future studies can explore indirect measures that can reveal attitudes and preferences toward diverse groups by prompting them in subtler ways, such as by running choice experiments that are quite common in the behavioral sciences.

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Appendices

A. Images from the VR Experience

The pictures below show still images of the VR experience for each group. The actual VR experienced by participants during the experiment were dynamic 360-degree videos. Links are provided to the videos.

Control Group (original state of Burns Garden)

Treatment 1 (Burns Garden enhanced with urban design elements)

Treatment 2 (Burns Garden enhanced with attendees from diverse groups)

Treatment 3 (Burns Garden enhanced with urban design elements & attendees from diverse groups)

B. Summary of Barriers to Park Use and Elements Added in the VR Experience

Table B.1. Barriers to park use and design solutions

Barriers found to park take-up	Design solutions
Fear of violence and being sexually harassed/assaulted. Usually triggered by; ○ Enclosed spaces with limited exit opportunities ○ Empty public parks, desolation ○ Absence of light, darkness ○ Lack of surveillance by wards, the general public, or the residents of surrounding establishments ○ Poor environmental quality	Create additional exit opportunities and minimize fences and walls Fill the space with people – facilitating eyes with the presence of others (bystanders), these are natural guardians Install adequate streetlights Security: Increase the number of park wardens, policing and surveillance by public or private security officers, place buildings with windows facing the park, install a tea kiosk operated by a salesperson Security: Closed-circuit television, add emergency phones or buttons Create safe territories; place group tables and benches (these generate a feeling of territoriality and ground ownership)
Fear of verbal threats. In the shape of; whistles, comments, teasing especially when women perceive the space to be actively controlled by a threatening male group or presence of drugs addicts and homeless men	Restrictions on boys entering a park as a group Place signals expressing that verbal threats are prohibited, such as whistles, comments, or teasing and/or that respect is encouraged
Lack of maintenance; "Broken window theory", women particularly are very sensitive to signs of social disorder such as; graffiti, unkept and abandoned buildings, trash	Clean up the park Place garbage bins for littering Place natural elements; shady trees, bushes, and tall grass
Lack of basic amenities and services	Install swings and other play fixtures Add facilities for outdoor physical activity, for instance, install a cycle track Toilets for men and women

Source: Facebook survey and review of the urban design literature by the World Bank team, including Whitzman (2007), Valentine (1989), Simonsen and Vaio (1996), Fenster (2005), Loukaitou-Sideris (2005), Paola (2007), Gilbert (1998), Gaffikin et al. (2010), Qutub and Anjum (2010), Condon et al (2007), Valentine (1990), Mazumdar and Mazumdar (2001), Hengehold (2011).

C. Summary Statistics

Table C.1. Summary Statistics

VARIABLES	(1) mean	(2) sd	(3) min	(4) max
Female (=1)	0.46	0.50	0.00	1.00
Urdu Speaker (=1)	0.77	0.42	0.00	1.00
Age (years)	23.98	4.46	18.00	30.00
Working (=1)	0.48	0.50	0.00	1.00
Education Below Median (=1)	0.63	0.48	0.00	1.00
Income Below Median (=1)	0.53	0.50	0.00	1.00
Survey Duration (minutes)	9.91	5.24	3.12	29.35

Notes: This table displays summary statistics for the sample of a selected group of characteristics.

D. Balance Checks

The treatment and control groups are balanced in the main variables, after dropping the top and bottom percentiles of participants in survey duration (Table D.1). Only 1 of 33 differences computed is significant at conventional significance levels, which indicates that the randomization was successful in achieving balance across treatments. By subgroups (tables available upon request), the treatment and control groups are also balanced in the main variables (after dropping the 1 percent tails of participants in terms of survey duration). Only 14 of 264 differences computed are significant at conventional significance levels, which indicates that on average the randomization was successful in achieving balance across treatments. However, we shall be careful when interpreting results for non-Urdu speakers and males, as they each have 6 and 5 significant differences at conventional significant levels.

Table D.1. Participant Characteristics and Covariate Balance

VARIABLES	[T1] Urban Design	[T2] Diversity	[T3] Urban Design + Diversity	Observations	Control Mean
VR/Survey Location	-0.04	-0.10	-0.19	1,924	9.06
	(0.350)	(0.353)	(0.348)		
Participant Sex	0.03	0.02	-0.02	1,924	1.45
	(0.032)	(0.032)	(0.032)		
Age (log)	0.00	0.02	0.01	1,924	3.15
	(0.012)	(0.012)	(0.012)		
Income Level Below Median	0.05	0.02	0.01	1,924	0.51
	(0.032)	(0.033)	(0.032)		
Education Level Below Median	-0.03	-0.02	-0.00	1,924	0.64
	(0.031)	(0.031)	(0.031)		
Studying/Working Status	0.09	0.06	0.08	1,924	2.27
	(0.073)	(0.073)	(0.073)		
Park User	-0.06	-0.07	-0.01	1,924	3.07
	(0.062)	(0.061)	(0.062)		
Worked with Outgroups on Projects	0.01	-0.01	0.06**	1,924	0.45
	(0.032)	(0.032)	(0.032)		
Non-Urdu Speakers	-0.02	0.00	-0.01	1,924	0.24
	(0.027)	(0.028)	(0.027)		
Before/After Ramadan	-0.00	-0.01	-0.01	1,924	0.19
	(0.026)	(0.025)	(0.025)		
Facilitator ID	0.00	0.03	-0.04	1,924	4.42
	(0.128)	(0.128)	(0.127)		
Participants with incomplete information	0.01	-0.00	0.01	1,964	0.02
	(0.009)	(0.008)	(0.009)		

Notes: This table shows the balance checks of all covariates. Robust standard errors are shown in parentheses. ***p<0.01 **p<0.05 *p<0.1.