ABSTRACT

RAWAL, SONIKA OMPRAKASH. Impact of Urban Park Design on Recovery from Stress: An Experimental Approach using Physiological Biomarkers. (Under the direction of Dr. Celen Pasalar)

Natural environments have been shown to help humans recover from stress and restore physical and mental health; by contrast, urban environments have been shown to hinder recuperation and amplify the hassles of everyday life. For city dwellers, urban parks act as a green oasis within the urban fabric and can help to meet the need for everyday restorative contact with nature. Previous studies in environmental psychology and person-environment behavior have reflected on the broad ‘natural’ versus ‘urban’ dichotomy; examined access to and distance from nature in association with stress; and measured restorative benefits of nature mostly within healthcare facilities where stress is prevalent. Even though now it is deeply ingrained that the experience of nature produces an array of positive benefits to mental well-being, much less is known about the specific attributes of green space that produce these effects. Most pertinent evidence uses self-reported health indicators as primary measures of health and has limited consideration of the design elements of green space, making it challenging to design urban green spaces for greatest restorative potential. The current translational study addresses this gap and investigates the design attributes of urban parks that are most associated with recovery from acute stress. A novel methodological protocol was developed that allows use of physiological biomarkers as pragmatic measure of stress, as well as Immersive
Virtual Environments (IVEs) to measure unambiguous design characteristics of natural environments and their impact on acute stress in people.

This study particularly looked at the amount of vegetation within an urban park to explore whether the recovery from acute stress was directly proportional to the amount of vegetation cover and whether the two shared a linear relationship. A multi-method approach was used for this investigation. Data were collected from 103 healthy participants who engaged in a quasi-experiment. Psychological stress was first induced in the participants using Trier Social Stress Test (TSST) and then they were randomly assigned to experience one of four, 360-degrees panoramic images of an urban park using Immersive Virtual Environment (IVE). Three groups viewed images of urban parks with density of vegetation varying from 3% to 70%, while the control group viewed an image with no nature elements. Participants provided saliva samples for alpha-amylase and cortisol measures and completed a State-Trait Anxiety Inventory (STAI) questionnaire at three time-points during the experiment. A structured interview was also conducted with the participants at the end of the experiment. Statistical analysis of data revealed multifold results. First, the Trier Social Stress Test (TSST) caused a significant elevation \((p<0.01)\) in the self-reported stress as well as physiological stress, making it an effective tool for psychological stress induction. Second, two-way repeated measures ANOVA results indicate that as the percentage of vegetation cover increases from barren to greener scenes, there is a rapid decrease in stress until the density of vegetation reaches about 50% of the visible space; higher densities predict higher stress.
Brief exposure to moderate density of vegetation brings about a significant decrease in stress levels ($p<0.01$) as compared to exposure to an environment with very few or no natural elements. This relationship holds after controlling for gender, age, and baseline stress levels. Third, content analysis of the participant’s narrative reveals similar but stronger association between vegetation density and perceived stress. An urban park with moderate amount of vegetation, along with presence of water, visual connection to built form, subtle play of levels and landform with points of interest and potential for affordance, was unanimously considered to create maximum recovery from daily urban stress. This study also confirms the potential of IVE to become a ubiquitous methodological tool for researchers investigating human perceptions, preferences and responses to built and natural environments.

The findings of this study expand the evidence base for well-being designers of the built environment and suggest that modifying urban green spaces by providing an enriched spatial configuration could increase the restorative quality of urban parks and offer extreme psychological benefits within a short amount of time. The methodological protocol established in this study can also be used in future studies that seek to test different environments for preference and restoration.
Impact of Urban Park Design on Recovery from Stress: An experimental approach using physiological biomarkers

by

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A dissertation submitted to the Graduate Faculty of North Carolina State University in partial fulfillment of the requirements for the degree of Doctor of Philosophy

Design

Raleigh, North Carolina 2016

APPROVED BY:

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DEDICATION

This dissertation is dedicated to my mother, whose unwavering love, perpetual support and incessant patience built the scaffolding upon which I stood as I strove to accomplish this. Words alone can never express the extend of my gratitude for her.
BIOGRAPHY

Sonika was born in Pune, India. Right from an early age, she was inclined towards all things creative and artistic, with her early artwork even been exhibited in Japan and London. Securing the first position in a drawing competition with the theme ‘World without Oil’ at the age of 8, was just the start for a new adventure and it embedded in her a keen interest in studies involving environmental issues. Pursuing a career in Architecture was just a matter of natural progression. Her undergraduate program satisfied her quest for energy efficient design and urban planning. Not only did she realize the role one should play in creating landmarks but also felt a deep requisite to work on it in configuration with the environment. This further deep rooted her inclination towards urban planning and sustainable design and she pursued masters in Urban Design program. Respect for the environment was always an imperative point in all her designs, which also reflected through her prize winning entry in ‘Zal N. Gobhai Design Award-2008’ for design of a ‘Zero-Energy Township’ in Pune Urban Area. To fulfill her passion for knowledge, Sonika began her PhD program at North Carolina State University in 2010, with an interest in designed environments and human health.

Sonika was privileged to work under the direction of Dr. Celen Pasalar at the College of Design for three years. During this time, she worked on a number of projects with Dr. Pasalar, from facilitating participatory design workshops in communities to conducting post-occupancy evaluations of bus transit stations. Sonika has presented her research
work at the Environmental Design Research Association (EDRA) and she was among the
top 10 finalists of the first 3 Minute Thesis (3MT) completion hosted by the Graduate
School at NC State University in 2015. Sonika’s interest in Geographic Information
Systems (GIS) also got her enrolled in the program where she earned the Graduate
Certificate in GIS from NC State University in 2013. Her current work allowed her to
work with the Center for Earth Observation Lab (CEO) at NCSU and gain hands-on
experience working with state-of-the-art Immersive Virtual Reality Environments (IVEs)
technology. Her current research study also gave her the opportunity to work at the
Salimetrics Center of Excellence Lab at the Bio-Behavioral Laboratory in the School of
Nursing, UNC, Chapel Hill.

Along with academics, the urge for understanding and learning the practical application
of design encouraged her to take up a number of small projects during undergraduate
and graduate program. Currently a registered Architect in India, Sonika has over 5 years
of work experience of design practice in India, with a wide range of projects including
commercial, hospitality, residential and landscape design. She also served as a lecturer
for Architectural Drawing and Architectural Design Studio in India. In 2013, she began
working as an intern at a design firm in Durham NC.

Apart from academics, extracurricular activities have always been an inseparable part
of her life. They have helped her discover her talents, develop a positive outlook, shape
her personality, enhance her thinking capability and helped her make countless friends. During her undergraduate studies, she had the opportunity to represent and lead her college at the conventions held by the National Association of the Students of Architecture (NASA), that conducted competitions among design schools at national level. At NC State University, she served as the web-designer, event organizer and member of the advisory committee for MAITRI (Indian Graduate Student Association). She has also volunteered with different groups including Service Raleigh, Habitat for Humanity and Unforgotten Fund. But work and studies do not keep her from her creative outlet. Sonika still continues to sketch and paint. One of her paintings ‘Lady in Red’ was selected by the Arts Center at NC State during the ‘Student Art Purchase-2013’ and is now a part of NC State’s permanent art collection. Her work is also on display in restaurants and lounges in Raleigh and she also hosts an online webpage to display and sell her artwork.

Sonika strongly believes that desire to learn, combined with an understanding of the fundamentals of structure and design, an appreciation of art and culture and a keen eye for detail are strengths that will hold her in strong stead. She trusts that her flair for logical thinking, innovative vision and analytical power offer her a foundation for a career in research. She intends to continue her research on mental well-being of people and follow her passion to improve human health through design solutions.
Namaste: ‘The Spirit within Me salutes the Spirit in You’

I am extremely indebted for the opportunity to embark upon and complete this journey. This journey has taught me so much not just about myself but also about my profession and the unbounded research in design. I realized that I was the happiest when I was fully engaged in work I enjoyed on this journey towards the goal that I had established for myself. I am far from what I once was, but not yet what I am going to be. This dissertation is just the beginning of a remarkable research journey ahead of me. Hopefully, I will never cease to explore further insights into design research and forever stay passionately curious.

This dissertation is a product of a colossal amount of external assistance that enhanced my productivity and minimized my shortcomings whenever possible and I have so many people to thank for their support in achieving this. I would like to express my deepest appreciation to all my committee members who have the attitude and substance of a genius; who continually and convincingly convey a spirit of adventure in regard to research and an excitement in regard to teaching. They have all been open-minded and demonstrated equal capacity to both lead and to listen. Without their guidance and persistent help this dissertation would not have been possible. Words alone can never fully express the extend of my gratitude for their support.
First and foremost, I would like to sincerely thank my advisor and mentor Dr. Celen Pasalar for her kind support, remarkable patience and trenchant critiques which made this work possible. Without her help and inspiring guidance, understanding the nature of research would have been unimaginable for me. I am in awe of her endowment, diligence and contagious enthusiasm in research and teaching. She tirelessly pursues academic and ethical excellence, yet is also extraordinarily generous and kind to the people she encounters along the way. I am thankful to her for devoting so much time and effort for my work, for always trusting me and encouraging me to perform better. I am extremely grateful to Dr. Roger Mitchell, who has been so sympathetic about my work right from the very beginning and been exceedingly insightful and patient all along this arduous but worthwhile journey. The vast amounts of research and statistical analysis I found myself struggling to cope with in this endeavor became more manageable with every meeting we had together. I would like to gratefully acknowledge the enthusiastic supervision of Dr. Myron Floyd, whose probing questions and wise counsel throughout this process have been invaluable. His insistence on methodological and statistical rigor challenged me to think critically about the research process and greatly facilitated this dissertation. I would like to thank Prof. Arthur Rice, for sharing his vast experience and knowledge in the profession of landscape architecture and for his invaluable insights on design of urban parks. His constant support and direction helped me make daunting task manageable and achievable.
I would like to thank Dr. Jordan Smith and Makiko Shukunobe from the ‘Center for Geospatial Analytics Geo-Visualization Laboratory’ at NC State University for extending their technical knowledge, support and equipment for developing and projecting the immersive virtual reality environments used in this study. Many thanks to Arsalan Abbasi whose expertise in Adobe Photoshop helped me create and modify the panoramic images for the virtual environments.

I am grateful to the hundred plus students of NC State University who volunteered to participate in this experimental study and whose responses provided the core for this dissertation research. I thank them for their time, permission to use their information as well as their valuable insights. This research would not exist without them. I would especially like to acknowledge the unfailing support of my friends Dr. George Hallowell and Robby Layton who generously took time off their busy schedules and served as panelists during my data collection phase. The support they provided, with the level of care and commitment, is way beyond compensation and I shall forever be in debt. I cannot miss to thank Mary Anne Bifulco and Mohsen Ghiasi for assisting with this process as well. I would also like to thank Ozlem Demir for letting me photograph and record her for documentation of the experimental procedure used in this study.

I would like to acknowledge the support I received from Dr. Eric Hodges and Brant Nix at the Bio-Behavioral Lab at UNC, Chapel Hill, who granted me access to their
‘Salimetrics, LLC- Center of Excellence’ laboratory facility for salivary hormone analysis. My special thanks goes to Victoria Benson for pushing me out of my comfort zone, instilling confidence in me to perform the sample analysis myself and training me for the same. I am grateful to her for being particularly tolerant and patient with me as she guided me through the procedures which are probably just second nature to her.

I am also overwhelmed by my years at NC State University. It has been an exceptionally rewarding journey. I am thankful to all my friends at the College of Design for their incessant help, care, intellectual exchanges, encouragement and discussions that go beyond the academic boundaries. I have learnt so much from each and every one of them, both professionally and personally. And cheers to the numerous other friends I made in the US. They have been my support system during this journey and have provided me a home away from home. The process of attaining my Ph.D. might have helped me accomplish one goal, but just as notably, it has given me innumerable friendships and memories that I will cherish for a lifetime.

Whatever the weaknesses of this dissertation, they would have been far greater without the loving and undying support of my mother. I fall short of language to express my gratitude for her absolute confidence and belief in me. She raised me as a strong, independent and ambitious girl and has always motivated me to follow my heart and face challenges fearlessly.
And finally, a special smile, a special face, a special someone I can't replace. There has been no end to my husband Vishal Trehan’s unflinching emotional, intellectual, technical and financial backing in achieving this milestone. He celebrated the high points with me, picked me up at my low times, provided solid unbiased advice when needed, helped me maintain sanity with his camaraderie and humor, tolerated my absence, kept me focused and cheered me on. Always!

This has truly been a community effort and I invite everyone involved to share in my sense of accomplishment (and relief) in having it done! In conclusion, I bring my hands together and take a deep bow to all of you in profound respect and absolute gratitude.

Namaste

Sonika Rawal
June 2016
# TABLE OF CONTENTS

| ABSTRACT | .................................................................................................................. | i |
| DEDICATION | ............................................................................................................... | ii |
| BIOGRAPHY | ............................................................................................................. | iii |
| ACKNOWLEDGMENTS | ..................................................................................................... | vi |
| LIST OF TABLES | .......................................................................................................... | xvi |
| LIST OF FIGURES | ............................................................................................................ | xviii |

## CHAPTER 1: INTRODUCTION .................................................................................. 1

1.1 Current Health Situation in Urban Environments ........................................... 3
1.2 Missing Link between Urban Parks and Mental Well-being ......................... 7
1.3 Purpose Statement ......................................................................................... 9
1.4 Significance of the Study .............................................................................. 11
  1.4.1 Contribution to Environment- Behavior Research .................................. 11
  1.4.2 Methodological Innovation ..................................................................... 12
  1.4.3 Design Implications from Empirical Findings ......................................... 14
1.5 Organization of this Dissertation: ............................................................... 15

## CHAPTER 2: LITERATURE REVIEW .................................................................... 18

2.1 The Concept of Healing / Health: ................................................................. 20
  2.1.1 Understanding Health, Well-being and Quality of Life: ......................... 20
    2.1.1.1 What Is Health? .............................................................................. 21
    2.1.1.2 What is Wellness or Well-being? ................................................... 22
    2.1.1.3 What is Quality of Life? ................................................................. 23
  2.1.2 Evolution of Health Concept: .................................................................. 24
    2.1.2.1 Pathogenic Approach: What Makes People Sick? ......................... 25
    2.1.2.2 Salutogenic Approach: What Makes People Healthy? .................... 27
  2.1.3 Understanding Mental Health: ................................................................. 29
    2.1.3.1 Physical and Mental Health Interrelationships: ............................. 30
    2.1.3.2 Urban Stress as a Determinant of Mental Health: .......................... 32
    2.1.3.3 Environmental Impacts on Mental Health: .................................... 37
2.2 Healing and Therapeutic Environments: ..................................................... 39
  2.2.1 Evolution of Green Spaces as Healing/ Therapeutic Environments: ...... 40
  2.2.2 Contemporary Urban Parks as Healing / Therapeutic Environments: . 43
2.2.3 Restorative/ Therapeutic Attributes of Urban Parks: 46
  2.2.3.1 Interpreting the Park Environments: 48
  2.2.3.2 Exploring the Visual Elements in Urban Parks: 50
  2.2.3.3 Identification of Park Attributes linked with Restoration: 52

2.3 Theoretical Approaches to Healing/Therapeutic Environments: 54
  2.3.1 Attention Restoration Theory (ART): 55
  2.3.2 Stress Reduction Theory (SRT): 57
  2.3.3 Theoretical Approaches: Brief Summary 61

2.4 Empirical Findings on How Nature Nurtures: 63
  2.4.1 View of Nature: 66
  2.4.2 Presence in Nature: 71
  2.4.3 Active Engagement with Nature: 77

2.5 Summary of Literature Review and Knowledge Gap: 80

CHAPTER 3: CONCEPTUAL FRAMEWORK: 82
  3.1 The Conceptual Framework: 82
  3.2 Research Questions and Hypothesis: 87

CHAPTER 4: RESEARCH METHODOLOGY: 94
  4.1 Research Design Overview: Multi-Method Strategy: 95
  4.2 Research Design: 96
    4.2.1 Method 1: Quasi- Experimental Design: 97
    4.2.2 Method 2: Stress Induction using Trier Social Stress Test (TSST): 102
    4.2.3 Method 3: Salivary Cortisol/Alpha-Amylase Measurement: 105
    4.2.4 Method 4: Immersive Virtual Reality Environment: 109
    4.2.5 Method 5: Structured Interview: 113
  4.3 Development of Research Instrument: 114
    4.3.1 Image Selection for the Quasi-Experiment: 114
      4.3.1.1 Photographic Survey: 115
      4.3.1.2 Images for Immersive Virtual Reality Environment: 119
      4.3.1.3 Image Modification: 125
    4.3.2 Quasi-Experiment Setup: 127
      4.3.2.1 Sample Size and Effect Size: 127
      4.3.2.2 Participants: 129
      4.3.2.3 Trier Social Stress Test (TSST) Panel: 130
      4.3.2.4 Treatment and Control Group Images for IVE: 131
  4.4 Data Collection / Quasi-Experimental Procedure: 131
4.4.1 Step 1 - TSST Setup ......................................................................................... 132
4.4.2 Step 2 - Introduction and Basal Measures: .............................................. 134
4.4.3 Step 3 - Stress Induction through The Trier Social Stress Test (TSST): 135
4.4.4 Step 4 - Nature Treatment (NT): .............................................................. 139
4.4.5 Step 5 - Semi-Structured Interview: ......................................................... 140
4.4.6 Step 6 - Debriefing: .................................................................................... 141

4.5 Stress Measures: .............................................................................................. 142
4.5.1 Perceived Stress Scale (PSS) Score: .......................................................... 142
4.5.2 Saliva Samples collection and handling: ................................................. 143
4.5.3 Testing for Saliva Alpha Amylase Assay: ................................................. 145
4.5.4 Testing for Saliva Cortisol Assay: .............................................................. 148

CHAPTER 5: DATA ANALYSIS .............................................................................. 153
5.1 Descriptive Analysis of the Participant Sample........................................... 155
5.2 Stress-Inducing Effect of Trier Social Stress Test ....................................... 161
5.3 Interrelation among the three measures of Stress Responses...................... 166
5.4 Stress Recovery in Control Group versus Treatment Group ..................... 170
5.4.1 Analysis of STAI scores: .............................................................................. 170
5.4.2 Analysis of Salivary Alpha-Amylase Levels ............................................. 172
5.5 Stress Recovery in Control and the three Treatment Groups ................. 179
5.5.1 Analysis of STAI Scores: .............................................................................. 180
5.5.2 Analysis of Salivary Alpha-Amylase Levels ............................................. 183
5.6 Analysis of the Semi-Structured Interview Responses ............................. 200

CHAPTER 6: DISCUSSIONS .................................................................................... 209
6.1 Quantitative Findings ...................................................................................... 210
6.1.1 Nature exposure aids faster recovery from stress .................................... 210
6.1.2 Levels of Stress change with changes in Vegetation Densities .............. 211
6.1.3 Levels of Stress change are consistent across Gender and Race/ Ethnicity .............................................................................................................. 213
6.1.4 Trier Social Stress Test (TSST) is a reliable tool for stress induction in laboratory setting........................................................ 215
6.1.5 Physiological measures are reliable for quantifying Stress in Design Studies .................................................................................................. 216

6.2 Qualitative Findings ....................................................................................... 217
6.2.1 Moderately Dense and Complex Park is most effective for Stress
Recovery ........................................................................................................ 217

CHAPTER 7: CONCLUSIONS ........................................................................... 221
  7.1 Main Conclusion of the study ................................................................. 221
  7.2 Strengths of the Study ............................................................................ 222
    7.2.1 Contribution to Environment- Behavior Research ......................... 222
    7.2.2 Methodological Innovation .............................................................. 223
  7.3 Limitations of the Study ....................................................................... 224
    7.3.1 Statistical Limitation ....................................................................... 225
    7.3.2 Methodological Instrument Limitation ........................................... 226
    7.3.3 Outcome Measurement Limitation ................................................. 227
    7.3.4 The Challenge of Defining Less Measurable Attributes ............... 227
    7.3.5 Lack of External Validity ................................................................. 228
  7.4 Implications for Future Policy, Design and Research ......................... 229
  7.5 Recommendations for Future Studies .................................................. 230
  7.6 Subjective Claims .................................................................................. 233

REFERENCES ................................................................................................. 235

APPENDICES .................................................................................................... 255
  Appendix A: Photographic Survey Questions ........................................... 255
  Appendix B: GigaPan Epic Pro User Manual ............................................ 256
  Appendix C: IRB Approved- Call for Participation / Advertisement: .......... 258
    Appendix C.1: Email communication: .................................................. 258
    Appendix C.2: Flyer ............................................................................... 259
    Appendix C.3: Advertisement on Facebook and other Social Media: .... 260
  Appendix D: Randomized Distribution of Participants in 4 Groups .......... 261
  Appendix E: IRB Approved Informed Consent Form ............................... 262
  Appendix F: IRB Approved - Demographics and Health Questionnaire.... 265
  Appendix G: IRB Approved - Perceived Stress Scale Questionnaire ....... 267
  Appendix H: IRB Approved - Script for Trier Social Stress Test (TSST) ..... 268
  Appendix I: IRB Approved - Post-TSST Self-Evaluation Questionnaire: .... 270
  Appendix J: IRB Approved - Post-Treatment Self-Evaluation Questionnaire 271
  Appendix K: IRB Approved - Park Use Questionnaire ............................. 273
  Appendix L: IRB Approved - Park Preference Questionnaire .................. 275
  Appendix M: IRB Approved - Semi-Structured Interview Guide ............. 277
  Appendix N: IRB Approved – Debriefing Script ....................................... 279
Appendix O: Salimetrics Oral Swabs (SOS) usage instructions ............... 280
Appendix P: Salimetrics- Salivary Alpha-Amylase Kinetic Enzyme Assay Kit
Information .............................................................................................................. 282
Appendix Q: Salimetrics- Salivary Cortisol Enzyme Immunoassay Kit
Information .............................................................................................................. 283
LIST OF TABLES

Table 1: Sample Size Determination ................................................................. 128
Table 2: Participant Sample Description ........................................................... 158
Table 3: Descriptive Analysis of Participant's Major/ Department ...................... 159
Table 4: Participants' Perceived Stress Scale Scoring ......................................... 160
Table 5: Increase in Salivary Alpha-Amylase Post-Stressor ................................ 162
Table 6: Gender Differences in Increase in Salivary Alpha-Amylase Post-Stressor ... 163
Table 7: Increase in Salivary Cortisol Post-Stressor .......................................... 164
Table 8: Gender Differences in Increase in Salivary Cortisol Post-Stressor .......... 165
Table 9: Correlation Analysis between decrease in Salivary Alpha-Amylase levels, Salivary Cortisol levels and STAI Scores .............................................................. 167
Table 10: Descriptive Statistics for STAI Scores- Control versus Nature-Treatment Groups .......................................................................................................................... 170
Table 11: Analysis of STAI Scores Post-Treatment: Control versus Nature-Treatment Groups .............................................................. 171
Table 12: Distribution of participants in the Control and Nature Groups ............ 173
Table 13: Participant’s Salivary Alpha-Amylase Levels Pre-Stressor, Post-Stressor and Post-Treatment .................................................................................................................... 174
Table 14: Analysis of Salivary Alpha-Amylase Levels: Control versus Nature-Treatment Groups .......................................................................................................................... 175
Table 15: Mauchly’s Test of Sphericity ................................................................. 176
Table 16: Analysis of Salivary Alpha-Amylase Levels: Control versus Nature-Treatment Groups .......................................................................................................................... 177
Table 17: Analysis of Salivary Alpha-Amylase Levels: Control versus Nature-Treatment Groups .......................................................................................................................... 178
Table 18: Distribution of Participants in 4 Treatment Groups ............................ 180
Table 19: Analysis of STAI Scores between 4 Treatment Groups ....................... 180
Table 20: Post-Hoc Analysis of STAI Scores within 4 Treatment Groups .......... 182
Table 21: Descriptive Statistics of Salivary Alpha-Amylase levels: 4 Treatment Groups .............................................................................................................................. 184
Table 22: Analysis of Salivary Alpha-Amylase levels between 4 Treatment Groups . 186
Table 23: Mauchly’s Test of Sphericity ................................................................. 187
Table 24: Analysis of Salivary Alpha-Amylase levels across Gender and Ethnicity ... 189
Table 25: Trend Analysis of Salivary Alpha-Amylase levels - 4 Treatment Groups ... 190
Table 26: Test for Equality of Variance ................................................................. 191
Table 27: Post-Hoc Analysis of Salivary Alpha-Amylase levels across time and between groups ................................................................. 193
Table 28: Analysis of Salivary Alpha-Amylase levels across Gender ............... 194
Table 29: Descriptive Statistics of Salivary Alpha-Amylase levels across Race/ Ethnicity.......................................................................................... 196
Table 30: Analysis of Salivary Alpha-Amylase levels across Race/ Ethnicity .... 196
Table 31: Semi-Structured Interview Responses .................................................. 201
Table 32: Vegetation Density Preference from Images ......................................... 206
Table 33: Themes from Semi-Structured Interview Responses .......................... 208
LIST OF FIGURES

Figure 1: Overview of this Dissertation ................................................................. 17
Figure 2: Topics covered in Literature Review .................................................... 19
Figure 3: Health outcomes of Chronic Stress ..................................................... 31
Figure 4: Benefits of Urban Parks ........................................................................ 45
Figure 5: Conceptual Models for understanding Built and Natural Environments ... 49
Figure 6: Kaplan’s Understanding-and-Exploration Preference Matrix ................ 51
Figure 7: Attributes of Parks emerging from Environmental Psychology and 
    Environmental Aesthetics Theories (Hunter & Askarinejad, 2015) .............. 53
Figure 8: Integrated Framework of ART and SRT ............................................. 62
Figure 9: Benefits of Contact with Nature .......................................................... 65
Figure 10: Elements of Urban Park ..................................................................... 84
Figure 11: Vegetation Types ................................................................................ 85
Figure 12: Conceptual Framework ...................................................................... 86
Figure 13: Research Approach ............................................................................ 94
Figure 14: Image Selection Process .................................................................... 114
Figure 15: Examples of Pullen Park Images ....................................................... 116
Figure 16: Examples of Marla Dorell Park Images ............................................ 116
Figure 17: Examples of Latta Park Images .......................................................... 116
Figure 18: Examples of Falls Park Images ......................................................... 117
Figure 19: Examples of Finlay Park Images ........................................................ 117
Figure 20: Examples of Piedmont Park Images .................................................. 117
Figure 21: Examples of Morgan Falls Park Images .......................................... 118
Figure 22: Examples of Historic Fourth Ward Park Images ......................... 118
Figure 23: Process for creating Immersive Virtual Environment as per Smith(2015) . 121
Figure 24: Process for creating Immersive Virtual Environment (contd.) as per Smith (2015) ................................................................. 122
Figure 25: Image projected through Oculus Rift head-mounted device ............ 124
Figure 26: Selected Image: Moderate Density Vegetation ............................... 125
Figure 27: Modified Image: Low Density Vegetation ........................................ 126
Figure 28: Modified Image: High Density Vegetation ...................................... 127
Figure 29: Selected Image: Control Group ....................................................... 127
Figure 30: Experiment Procedure ................................................................. 132
Figure 31: Waiting Area and Interview Room .................................................. 132
Figure 32: SalivaBio Oral Swabs from Salimetrics .................................................. 135
Figure 33: Panel of Interviewers for TSST ................................................................. 137
Figure 34: Participant experiencing Immersive Virtual Environment ...................... 140
Figure 35: Workspace in Salimetrics Center for Excellence Laboratory, UNC ......... 144
Figure 36: Salivary Alpha-Amylase Assay Kit ............................................................. 146
Figure 37: Jitterbox and BioTek Microplate Reader ................................................. 148
Figure 38: Salivary Cortisol Enzyme Immunoassay Kit .......................................... 150
Figure 39: Additional Images from Salimetrics COE Laboratory .............................. 152
Figure 40: Data Analysis Flow .................................................................................. 154
Figure 41: Sample Size ............................................................................................. 156
Figure 42: Distribution of Participant's Major/ Department ........................................ 159
Figure 43: Correlation between STAI Scores, Salivary Alpha-Amylase and Salivary Cortisol Post-Stressor ................................................................. 169
Figure 44: Correlation between STAI Scores, Alpha-Amylase and Salivary Cortisol Post-Treatment ................................................................. 169
Figure 45: Stress Reduction using STAI Scores: Control versus Nature-Treatment Groups ............................................................................................................. 171
Figure 46: Stress Reduction using Salivary Alpha-Amylase Levels: ......................... 174
Figure 47: Salivary Alpha-Amylase Responses to Stressor and Treatment: ............ 178
Figure 48: Stress Reduction using STAI Scores: 4 Treatment Groups .................... 182
Figure 49: Stress Reduction using STAI Scores by Gender: 4 Treatment Groups..... 183
Figure 50: Stress Reduction using Salivary Alpha-Amylase levels- 4 Treatment Groups ............................................................................................................. 185
Figure 51: Salivary Alpha-Amylase Responses to Stressor and Treatment: 4 Treatment Groups ................................................................................................. 192
Figure 52: Salivary Alpha-Amylase Responses to Stressor and Treatment by Gender: 4 Treatment Groups ................................................................................. 195
Figure 53: Differences in Stress-Responses between 4 Treatment Groups by Gender 198
Figure 54: Differences in Stress-Responses between 4 Treatment Groups by Race/ Ethnicity .............................................................................................................. 199
Figure 55: Vegetation Density Preference from Images ............................................ 206
Figure 56: Balanced Composition of Park that allows for variety of experiences ...... 219
CHAPTER 1: INTRODUCTION

‘Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity’, states the World Health Organization (1946). However, the current focus in this important area seems to be on reducing diseases, while less attention has been given to increasing the well-being of populations. The adverse health effects of urban sedentary lifestyles combined with modern diets have led to an obesity epidemic that has raised concerns across all disciplines globally. Consequently, more and more emphasis has been laid on the importance of physical activity and active living concepts. But, on the other hand, there is mounting evidence that mental ill-health has now become a substantial health issue for many cohorts of people. Today, mental ill-health caused by daily stress and depression, especially in urban living environments, is one of the world’s most serious public health issues and is still largely overlooked (Anderson et al., 2015; Anderson et al., 2013).

Growing body of research recognizes that the built environment (including the physical structures and infrastructures) and the natural environment (including parks, greenways, lakes, etc.) play a significant role in shaping human health (Frank et al., 2003; Wheeler, 2004). In particular, it is incontestable that the natural environment is a key determinant of health. Various studies provide evidence that exposure (both passive and active), and access, to natural environment can have a wide range of social, economic,
environmental and health benefits (Kawachi & Berkman, 2001; de Vries et al., 2003; Maas et al., 2006). In addition, evidence now indicates that exposure to nature has a significant positive effect on physical as well as mental health (Barton & Pretty, 2010).

Understanding how nature influences an individual’s mental health and well-being as well as behavior is an emerging theme both in the fields of design and environmental behavior research. Still, little is known about the about the strength of the relationship between nature and mental health, possible group differences among groups of people, and the spatial conditions (size, type, layout of green space) that promote beneficial effects of nature (van den Berg et al., 2007). Less explored are the precise design characteristics of green spaces that help people deal with daily stress, cope with depression, trigger optimistic mood changes and contribute towards positive experience of the green space thus enhancing overall mental well-being. Empirical research examining relationships between unambiguous park characteristics in association with stress reduction among people is less abundant but is growing.

This study is an inquiry into the relationship between urban park elements and acute stress recovery. First, it looks at the stress responses from exposure to nature and exposure to no-nature setting after a stressful event, to examine whether nature has any influence during the recovery period. Second, this study looks into the amount of vegetation within an urban park in association with recovery from stress and asks the
question: whether recovery from acute stress is directly proportional to the amount of vegetation cover and whether the two share a linear relationship. And in conclusion, this study also tries to gain a broader understanding of other design attributes of urban parks that offer restorative experiences.

1.1 Current Health Situation in Urban Environments

Health can be affected and enhanced by the environments in which individuals live and work. These settings are defined as physical spaces or social contexts where people engage in daily activities and where various factors, including environmental, organizational, and personal factors, work together to influence health and well-being (WHO, 1998).

Urban living is a pretty “new” concept in human history, but it has grown by leaps and bounds. People have been continually moving to cities from suburban areas over the past few hundred years (Brookshire, 2011). Currently, lured by the prospect of work and other opportunities, more than half the world’s population lives in cities. Due to rapid urbanization occurring in developing nations, this number will continue to increase. Habitat (2001) states that about 75% of the population in developed countries presently lives in dense urban areas (as cited in Van den Berg, Hartig, & Staats, 2007). United States of America also has one of the most urbanized population, with about 82% residing in urban areas (Central Intelligence Agency, 2007).
Cities are assumed to offer many opportunities and benefits, such as increase in resource efficiency, accessibility, and economic viability, better sanitation, nutrition, health care and so on (van den Berg et al., 2007). However, the reality is still far from the safe, clean and livable environments. The rise of chronic health conditions such as obesity, asthma, diabetes, heart disease, and depression has trended with rapid development, loss of habitat, and fragmentation of green space in urban environments (Jackson, 2003). The pressures of modern living in cities are precursors to increasing number of problems that we face today including increased risk for chronic illness, increased social stress, and larger social disparity.

Modern urban life is widely perceived as stressful as city dwellers typically face more noise, more crime and more homelessness. Also, urbanites often struggle to meet the demands of work, family, and other obligations against the backdrop of an environment that itself may contribute to a chronic experience of stress (Abbott, 2012). Many authors propose that social stress processing in the urban environment underlies the greater risk for mental illness and contributes to the manifestation of these disorders in adults (Peen, Schoevers, Beekman, & Dekker, 2010; Van Os, Kenis, & Rutten, 2010).

A recent report by Gallup-Healthways- Well-Being Index (2015) states that United States is ‘a nation under too much stress’, based on a nationwide survey analyzing the level of
stress experienced by individuals across the U.S. Almost 40.6% of Americans stated that they experienced stress ‘yesterday’ or the previous day. Almost 75% of Americans also stated that they experienced stress at least once in the past month (Anderson et al., 2015). Not just adults, but teens also report to experience stress in ways similar to adults. The survey demonstrated that teens have an average stress level of 5.8 on a 10-point scale during the school year, compared to a level of 4.6 during the summer. Furthermore, 31 percent of teens stated that their stress levels have increased over the past year (Anderson et al., 2014). Individuals also reported additional physical and mental health-related symptoms, such as headaches or feeling anxious or depressed due to stress, while acknowledging the change in behaviors and increase in unhealthy eating patterns due to stress. About 39% reported overeating or eating unhealthy foods while 31% of adults admitted to skipping a meal due to stress in the past month (Anderson et al., 2015). Overall, money (71%), work (69%) and the economy (59%) were the the most commonly reported sources of stress (Anderson et al., 2014).

Recent research results suggests that crowding, fear of crime and noise from traffic, all link to aggression and violence (Kuo & Sullivan, 2001). Kaplan (1995) notes that people living in cities are overwhelmed with contemporary lifestyles and urban environment such as discouraging and crowded places, advanced technology and increasing demands of modern life including traffic, phones, conversations, problems at work, and complex decisions. City life demands people to process information continuously and
minimizes people’s capacity to deliberately direct attention to healthy lifestyles and choices. As a result, more and more people are experiencing mental fatigue, a state characterized by inattentiveness, irritability, and impulsivity (Kuo & Sullivan, 2001). It is assumed that there is a strong association between cities, stress and mental health. Strong evidence demonstrates a higher concentration of psychiatric illnesses existing in the cities than in the rural areas or smaller towns (Lederbogen et al., 2011; Roe & Aspinall, 2011; Ulrich, 1981). Meta-analyses show that current city dwellers have a substantially increased risk for anxiety disorders (by 21%) and mood disorders (by 39%) (Lederbogen et al., 2011). There is also an increased risk for anxiety disorders, mood disorders, and schizophrenia.

There is also some evidence that living in a city can ‘bring on’ mental disorders. While many mental disorders are thought to have a genetic component to some degree, the addition of stress due to other factors may bring out an underlying mental illness (Abbott, 2012; Brookshire, 2011). Therefore, increasing attention is given to urbanization and its impacts concerning mental health. Many researchers (Guite, Clark, & Ackrill, 2006; Williams, 1994) recognize that nothing about mental health will become clear to unless there is more research investigating the true impact of our surrounding environment (Harry, 2010). Thus, more research is required to examine the urban environments, its components, and the specific means in which they impact mental well-being of people.
1.2 Missing Link between Urban Parks and Mental Well-being

The current mental health scenarios as described above, draws attention to the serious physical and emotional implications of stress and the inextricable link between stress and the urban environment. With increasing number of people moving to and living in cities, the urgency to understand the impact of urban design on mental health has never been greater. With one in four people having mental health problems at least once in their lifetime, it is believed that the design of cities can provide positive impact on public mental health concerns around the world. The environmental qualities of our cities can help maintain the population's mental health, support people when they have mental health problems, and promote their recovery. Therefore, the importance of green spaces has been of increasing interest to researchers examining the associations between green spaces and human health, particularly in urban environments.

The prevailing societal and health issues faced by urban residents today have lead to growing need for communal spaces within the urban environment. The rise of chronic health conditions has been augmented with the loss of habitats and availability of limited amounts of green spaces within the urban environments. With over 82% of the American population inhibiting the urban areas (World Urbanization Prospects: The 2014 Revision, Highlights, 2014), urban parks are increasingly gaining importance and can provide multiple benefits to urban residents. With ever-growing changes in the urban environment and decreasing urban green spaces, urban residents are more exposed to
landscape changes associated with rapid development and health matters (Jackson, 2003; Verheij, Maas, & Groenewegen, 2008). Many new urbanites and young families live in small condos located in high-rise and dense housing complexes. As a result, they expect that the city and urban centers will provide many of the features that house- owners in suburban and rural areas take for granted (for example: open fields, gardens, pleasing landscapes). Thus, parks now are not limited to being civic frills but have become an urban necessity. Green spaces provide people with places to relax and engage in physical activity (Cohen et al., 2007; Maller, Townsend, Brown, & St Leger, 2002). Urban life in general, and urban stressors are increasing motivating people to look for greener spaces in their neighborhoods. People’s diverse needs including contact with nature, aesthetic preferences, recreation and play needs, social interactions and privacy, citizen participation in design process and sense of community identity, etc. can be fulfilled when they visit urban parks (Zhai, 2014; Matsuoka & Kaplan, 2008). It is therefore essential to study how components of a park may promote, or prevent, the potential for psychological restoration through stays in the park (Nordh & Østby, 2013).

Landscapes used in previous studies have been described loosely and in coarse categories, mainly reflecting a broad ‘nature’ versus ‘urban’ dichotomy (Velarde, Fry, & Tveit, 2007a) or exploring access to (J Maas et al., 2009) and distance from green space (Catharine Ward et al., 2012). Much less information is available in the literature regarding specific landscape elements, structures and patterns within the urban and
natural categories. Research informs us that how people use and experience the green spaces within the urban environment can have strong influences on their mental health, from a glimpse of vegetation through office windows to spending time in community gardens. What has not been made clear, however, is the underlying conditions that are responsible for stress alleviation, especially those conditions related to the landscape’s physical and natural aspects. What still remains unknown is whether differently designed urban parks lead to different experiences (B. Jiang, Li, Larsen, & Sullivan, 2014; Hunter & Askarinejad, 2015) and thus different impacts on mental health. Though there is a lot of research on restorative environments, there is limited empirical evidence that provides information about the specific components or elements of the design of urban parks that aids this restoration. Most of the design approaches have focused on hospitals and health facilities where stress is prevalent among all groups of users, and to a lesser extent to urban design and the design of urban parks and green spaces (Dilani, 2001; Ulrich, 2002; Gesler, 2003). However, it is also important to extend the benefits of restorative environments to general populations and incorporate designed green spaces within their every day environments in support of maintaining their emotional and mental well-being.

1.3 Purpose Statement

In the face of accelerating urbanization and rising incidences of chronic illnesses, nature in the urban setting is a vital contributor to quality of life. Urban parks in particular act
as green stepping stones in the urban fabric and function as a compliment to the larger parks (Konijnendijk, 2013) and to some extent fill in the need for people's everyday contact with nature (Sempik, Hine, & Wilcox, 2010). It is known that contact with nature aids recovery from stress.

This research responds to the missing gap in literature and aims to uncover the specific design characteristics of urban parks that aid faster recovery from acute stress for people using the park. Trees, shrubs, grass and other forms of vegetation form an integral park of any green space or urban park and play an important role in structuring the entire space. Parks are usually experienced and perceived through the amount, type and form of greenness they provide. Therefore, the purpose of this study is to investigate what amounts of vegetation and other design characteristics of parks that can assist people with faster recovery from urban stress in people within the parks. This research also aims to provide empirical evidence to support the theory that an individual recovers from stress and handles anxiety more effectively even through brief contact with nature. Thus, this study contributes to the limited body of literature available about the inherent restorative properties of natural environments in urban contexts. On a broader scale, it attempts to explore the best dose of Vitamin G (Green Space) that can be recommended for sustaining good mental health.
A better understanding of the physical design characteristics of urban parks that are associated with stress reduction can be useful for designers to create places that are not only supportive of physical activity but also can promote mental well-being among the park users. Translating research into practice is not the foremost focus of this study, yet, providing empirical evidence on such issues is essential to inform and develop the future design interventions. Furthermore, it is expected that the identification of the restorative design characteristics of urban parks, that replicate many of the natural elements within the urban context, will provide useful information to landscape designers who desire to create urban landscapes intended to contribute to human health and activities.

1.4 Significance of the Study

The findings of this research are expected to make significant contributions to several areas including environmental-behavior research, methodological innovation and design implications based on empirical evidence.

1.4.1 Contribution to Environment- Behavior Research

Consistent with the theory of environment-behavior and environmental psychology research, the main findings of this study support the argument that exposure to the natural environment may be associated with and can influence well-being of people. There is growing body of knowledge that supports the belief that contact with or exposure to nature is beneficial for human health and enhances human well-being.
However, little, if any, research has been carried out to assess which components or characteristics of natural settings provide benefits to human health, especially in terms of stress levels. Existing literature on environmental research broadly classifies landscapes as ‘urban’, ‘rural’ or ‘natural’ and is also limited to examining health impacts in association with presence of nature, distance from nature and accessibility to nature. The current study aims at addressing this gap and providing better understanding about the extent to which urban park design characteristics influence the mental well-being of people.

1.4.2 Methodological Innovation

Methodological limitations in measuring the impact of park features in association with stress levels have resulted in less number of studies focusing on understanding how design of parks influences mental well-being of people. This study provides a systematic way of zooming in to the specific elements of nature that prompt restoration from acute stress. This study aims at establishing a protocol that can be applied to examine and study different design elements of urban parks in association with recovery from acute stress.

There are a number of ways of measuring stress, such as life events checklists, self-reported levels of chronic strain using scales like Perceived Stress Scale (PSS), State Trait Anxiety Inventory (STAI), daily hassles measures, daily diary approaches and interviews.
(Cohen, Kessler, & Gordon, 1995). Most studies in environment-behavior research measuring stress responses to different environments involve self reports which can be less reliable. Recently, increasing number of design and landscape design researchers have opted for more reliable methods to measure the impact of nature on human health including physiological biomarkers such as cortisol, skin-conductance, heart rate monitoring, brain activity using fMRI and blood pressure (Bin Jiang, Chang, & Sullivan, 2014; Catharine Ward et al., 2012; Lederbogen et al., 2011; Rodiek, 2002). With scientific and technological advancements, the use of these biomarkers has now become possible even outside laboratory and healthcare settings. Given the fact that stress is a physiological response (even if the determinants of stress are primarily psychological), this study uses salivary cortisol and salivary alpha-amylase as biomarkers of stress to provide more reliable and pragmatic results and thus will have wider acceptance and scientific relevance.

This study is also innovative in its approach to measure the design features of the urban park. The complexity of parks is broken down into five main design elements (vegetation, water, landform, structure and sky) and this study focuses on examining one element, i.e., vegetation. Technological advancements made it possible to use 360 degrees panoramic immersive virtual environments as a part of this experimental approach. This study confirms the efficacy of Trier Social Stress Test (TSST) as a tool for psychological stress induction and also the potential of IVE to become a ubiquitous
methodological tool for researchers investigating human perceptions, preferences and responses to built and natural environments. It thus establishes a protocol that can be used for examining any kind of urban environment, built or natural, in association with its impact on human health and behavior.

Both survey and interview data was collected in addition to salivary cortisol and salivary alpha-amylase to objectively measure the dependent variable—stress. Using both qualitative and quantitative methods increase the validity and reliability of the indicator measurements of stress and urban park design elements.

1.4.3 Design Implications from Empirical Findings

Researchers understand that it is important to educate the public about the importance of urban green spaces as the public in general does not comprehend the health benefits of nature. Urban designers and landscape architects play a leading role in such situations by bringing nature into the cities and creating spaces that have restorative effects. The findings of this research are expected to identify urban park design characteristics associated with recovery from stress in people. The goal of this study is to translate knowledge of the park design features into design guidelines that landscape architects and other designers can apply. This study statistically illustrates which design elements of urban parks are most effective in aiding recovery from acute stress among urban residents. The research does not just draw its conclusion on the statistical evidence;
rather, the findings are translated in to design recommendations. For landscape architects and urban designers, the findings of this study can provide practical insights on building healthy urban open spaces that foster both physical and mental well-being.

The study recognizes the fact that though people inherently connect with the natural and wild landscapes, these can’t be fully translated into urban environments. However, the findings of this study can enable identification of some elements that impart maximum restoration and can be transported to downtowns and similar effects of the wild landscapes can be obtained even within the limited green space in the urban environments. The study protocol established in this research to systematically examine and distinguish urban design features in association with stress recovery also has potential in both fields of design and research. The study also provides a framework for similar studies in the future, that can be understood and utilized by both researchers and designers and can therefore help bridge the gap between the research community and design community.

1.5 Organization of this Dissertation:

This dissertation is organized in seven chapters.

This first chapter introduces the current health conditions caused by rapid urbanization and the resulting urban stressors that affect the mental well-being of the urban residents.
It also talks about the importance of this study and how it can contribute to the efforts of proposing natural preventive measures in support of mental well-being.

‘Chapter 2’ reviews the existing literature relevant to the topic of this study. The literature review initially provided a broad overview of the concepts related to health, well-being and quality of life followed by more specific understanding of the mental health concepts. It then elaborates on the evolving concepts of therapeutic environments, such as urban parks and the specific health benefits of contact with nature, especially through urban parks, on mental health of its users. This chapter also sheds lights upon the existing theoretical approaches related to therapeutic environments and provides empirical evidences on how nature nurtures mental well-being of people. ‘Chapter 3’ presents the conceptual framework of this research study including the main research questions, the research hypotheses and the variables defined for this study. ‘Chapter 4’ highlights the research methodologies used in this study and describes the approach taken when developing the specific research instruments that were used for data collection. It also provides an in-depth description of the procedures that were followed for the data collection and stress measurement. ‘Chapter 5’ elaborates on how the data was collected, organized, managed, stored and analyzed. It summarizes the results of the data analysis. ‘Chapter 6’ reports the overall results, reflects on them and explains how the findings address the research questions of this study. Finally, ‘Chapter 7’ draws the main conclusions from the findings. The study findings are also compared with those
presented by the previous studies highlighting the underlying similarities and differences.

This chapter also discusses the strengths and limitations of the study, providing future implications for potential research and design efforts.

Figure 1 below is a graphical overview of this dissertation illustrating how this study is organized.

![Figure 1: Overview of this Dissertation](image-url)
CHAPTER 2: LITERATURE REVIEW

The value of interacting with nature within the urban settings is not a new concept. Within the last 25 years, the profession of landscape architecture has seen the specialty of therapeutic landscape design develop. Research in the fields of behavioral and environmental psychology laid the groundwork and sparked a renewed interest in the therapeutic capacity of nature. The literature review for this presents the role of landscape architecture in therapeutic design, discussing a range of work focusing on the therapeutic benefits of the natural environment as well as other health benefits of contact with nature.

This chapter begins with reviewing the broad concept of health and healing and then continues to expounding the pathogenic and salutogenic approaches in relation to health. It then explains mental health and its relationship with our every-day environments. A brief historical overview of the therapeutic/healing aspects of nature is also provided elaborating on urban parks as therapeutic environments in urban settings. This is followed by an examination of research on the benefits of and recommendations for incorporating nature in designed urban open spaces. Finally the chapter focuses on the description of empirical and evaluative research on therapeutic benefits of nature, especially through urban parks. Research studies evaluating the mental health benefits of contact with nature have been conducted at different scales, different geographic levels, as well as in different types of natural environments. The findings of these studies
aim to help accentuate and justify this research topic and provide valuable methodological insights. Figure 2 graphically illustrates the overall structure and relationship of the topics covered in this chapter.

*Figure 2: Topics covered in Literature Review*
2.1 The Concept of Healing / Health:

In the present world of science and technology, health is considered to be one of our most significant concern. In the past two decades, with the rise of life expectancy, public awareness of health related topics has also increased. In the past 20 years, not only has the body of research in health domain seen tremendous growth, but health education and health promotion are now recognized as ways to meet public health objectives and improve the success of public health and medical interventions around the world (Glanz, Rimer, & Viswanath, 2008).

It is now a known fact that being healthy implies maintaining a healthy lifestyle that incorporates wholesome nutrition, physical exercise, stress that is manageable and adequate sleep. However, maintaining health in different phases of our life is multifaceted and complex. A number of factors contribute towards the idea of being healthy and for a better understanding, it is important to take a closer look at the concept of health.

2.1.1 Understanding Health, Well-being and Quality of Life:

Health, wellness and quality of life are terms that are most commonly understood and interchangeably used. It is evident that health, wellness and quality of life are similar constructs, if not identical, and the key feature is the enunciation on positive. In other words, they all refer to positive health (Gill & Bedini, 2010).
2.1.1.1 What Is Health?

Health, being a complex notion, has been inferred and interpreted in diverse ways (Kepez, 2006). The commonly used word ‘health’ originated from the Old English word ‘hale’ or ‘hælþ’ that means ‘wholeness, a being whole, sound or well.’ This word can be traced back to the Proto-Indo-European root ‘kailo,’ which means ‘whole, uninjured, of good omen’. In Middle English, it also meant ‘prosperity, happiness, welfare; preservation, safety’ (Online Etymology Dictionary, n.d.). The World Health Organization (WHO) defines health as ‘a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity’ which is the most commonly adopted definition (World Health Organization, 1946). In the recent years, this definition has been embraced worldwide, across various disciplines and it clearly moves away from the traditional medical model that focuses on treatment of diseases. The Healthy People Initiative that began in 1979, promoted this shift of focus towards positive health. The widely cited statement of national health objectives, Healthy People, 2010, has two overarching goals of increasing the quality and years of healthy life of all Americans and eliminating health disparities (Guidry, Vischi, Han, & Passons, 2010). Health People 2010, seeks to increase the life expectancy and quality of life by helping individuals gain the knowledge, motivation, and opportunities they need to make informed decisions about their health.
2.1.1.2 What is Wellness or Well-being?

The dictionary defines wellness as ‘the quality or state of being in good health especially as the result of deliberate effort’ (www.merriam-webster.com/dictionary/wellness) or as ‘the state or condition of being in good physical and mental health’ (http://www.oxforddictionaries.com/us/definition/american_english/wellness).

The National Wellness Institute, established in 1977, defines wellness as ‘an active process through which people become aware of, and make choices toward, a more successful existence.’ Although there may be different interpretations and models of wellness, the National Wellness Institute identifies a general agreement on the features of wellness which state that wellness is conscious, self-directed and evolving process of achieving full potential; is multi-dimensional and holistic, encompassing lifestyle, mental and spiritual well-being, and the environment and is positive and affirming (www.nationalwellness.org). The term wellness was initially used by Dr. Halbert L. Dunn, chief of the National Office of Vital Statistics, who attempted to convey the positive aspect of health instead of just focusing on health in terms of disease and death (Zimmer, 2010). Dunn drafted his concept of ‘high-level wellness’, and defined wellness as ‘an integrated method of functioning, which is oriented toward maximizing the potential of which the individual is capable.’ He also states that an individual is required to maintain a continuum of balance and purposeful direction within the environment where he is functioning (Dunn, 1961). The World Health Organization (2006) defines
wellness as ‘the optimal state of health of individuals and groups.’ It states that there are two focal concerns: the realization of the fullest potential of an individual physically, psychologically, socially, spiritually and economically, and the fulfillment of one’s role expectations in the family, community, place of worship, workplace and other settings (Smith, Tang, & Nutbeam, 2006).

Similarly, well-being can be defined as ‘a good or satisfactory condition of existence; a state that is characterized by health, happiness and prosperity’ (www.dictionary.reference.com/browse/wellbeing). Well-being is often characterized by health, but it is more than just good health. Well-being describes a state of body, mind and soul, where all are in a state of health; the individual is happy and prospering. A person who experiences well-being is whole or complete (Nelson & Prilleltensky, 2010).

2.1.1.3 What is Quality of Life?

On many occasions, quality of life is a term used instead of positive health or wellness or well-being. Health professionals as well as the general public refer to quality of life as a marker for positive health. The term quality of life (QoL) refers to the general well-being of individuals and societies. The World Health Organization (WHO) has defined quality of life as ‘an individuals' perceptions of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations,
Standards and concerns’ (Harper, 1996). This definition is a broad concept affected by the person's physical health, psychological state, personal beliefs, social relationships and their relationship to salient features of their environment. Quality of life can be an indicator of the values that exist in the community. Primarily, quality of life can be explained as both subjective and multidimensional. The subjective aspects allows it to be measured from the patient's perspective whereas the multidimensional aspect allows the researcher to investigate a range of concepts including well-being, functional ability, emotional well-being, and social well-being (Felce & Perry, 1995).

2.1.2 Evolution of Health Concept:

In the present world of technology and science, there is not a single day that passes without some news about health. It is now common knowledge that the environment around us affects health (Tountas, 2009). With the life expectancy above what it was a couple decades ago, public awareness of health related topics has increased. The understanding and definitions of health have changed over time (Klocek, 2012). Even though health is considered to be broad conceptually, it narrows down empirically as we focus on specific dimensions of everyday life and experience (Eyles & Williams, 2008). Being healthy is now commonly linked with maintaining a healthy life style that incorporates healthy nutrition, physical exercise, and no more stress than is manageable (Kepez, 2006). The factors associated with being healthy are also subjective, and largely also depend on the decisions we make based on our perceptions and preferences.
Maintaining health in different dimensions of our life is multi-faceted and complex. For a broader understanding, it’s inherently important to have a closer look at the evolution of the health concept (Kepez, 2006; Tountas, 2009).

The evolution of the health concept followed these steps: (1) Pathogenic Approach: The definition of “What makes people sick?” and (2) Salutogenic Approach: The call for defining “What makes people healthy?”

2.1.2.1 Pathogenic Approach: What Makes People Sick?

The early efforts in the health discipline are regarded as the pathogenic perspective or model that emphasized the development of ill-health and sickness (Stokols, 1992; Kepez, 2006). The word ‘pathogenesis’ comes from the Greek word pathos (disease) and genesis (creation). The Dictionary of Medicine, Nursing, and Allied Health defines ‘pathogenesis’ as ‘the development of morbid conditions or of disease; more specifically the cellular events, reactions and other pathogenic mechanisms occurring in the development of disease (2003).

The term ‘pathogenesis’ can thus be said to describe the source and development of the disease, and determine whether it is acute, chronic or recurrent. Earlier efforts in health practice and medical sciences opted the pathogenic approach to study the affected and sick body parts in isolation of the whole (Antonovsky, 1979; Tountas, 2009). Research
focused on understanding the course of illness from its initial manifestation through its critical development (Klocek, 2012; Tountas, 2009). Doctors, researchers and scientists worked towards the identification of the pathogen and ways to eliminate it. (Wayne, 2005). Thus, people who were attacked by a pathogen were called sick or ill, and when the effect of the pathogen was defeated, people returned to their health.

Undoubtedly, the concentrated pathogenic approach to identify the cause of illness stimulated the intellectual development of invaluable advances in the medical sciences. However, Antonosky pointed out some major limitations of this approach. First, he illustrates how the pathogenic approach forces us to concentrate on the disease, the illness, the alteration of the body fluids or structures and to disregard the sickness. It averts us from the subjective interpretation of the state of affairs of the person who is ill, limits us to an etiologic focus on the disease and fails to answer ‘what caused this specific disease’. Second line of criticism focused on the lack of multiple causality of disease. While the pathogenic paradigm opts the ‘magic-bullet’ approach, that is, one disease-one cure, it seldom can account for much of the variance in development of a disease in either populations or individuals. The third limitation of the pathogenic approach is how it takes for granted that a state of disease is qualitatively and dichotomously different from the state of non-disease. It blinds us to a concept that a person is always either with absolute health or has absolute illness (Antonovsky, 1979; 1990).
However, the loss and gain of health is not an instantaneous event but an occurrence that happens over a continuum during the lifetime of people. A loss of health status happens under different conditions that have biological, psychological, and social reasons (Kepez, 2006). The pathogenic approach is an incomplete explanation of human illness and disease since it ignores the contribution of numerous physical and social dimensions of the environment that can affect health (Antonovsky, 1979; Stokols, 1992; Lawrence; 2002). A salutogenic approach offers a more viable alternative to the holistic understanding of health and sickness.

2.1.2.2 Salutogenic Approach: What Makes People Healthy?

The World Health Organization (WHO) states that ‘health’ is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (WHO, 1946). The Ottawa Chapter for Health Promotion further defined health as ‘a resource for everyday life, not the objective of living. Health is a positive concept emphasizing social and personal resources, as well as physical capacities’ (WHO, 1986).

These definitions were the foundations of Antonovsky’s concept of salutogenesis (Antonovsky, 1979) which contradicts the pathogenic approach and questions health from the other side. The salutogenic model asks ‘Why do people maintain good health’, which is a more complicated question than what the pathogenic model solicits as ‘Why
do people fall sick?’ The answer to this cannot go beyond the exposure of sick people to risk factors and is therefore an incomplete explanation of health (Kepez, 2006). Antonovsky’s new approach, which amasses knowledge about the conditions for health, investigates the reason why some people remain in good health in spite of being exposed to risk factors. This concept takes account of the reasons and circumstances for the creation and preservation of health. The salutogenic model outlines health on a continuum, the edges of which form total health on one side and disease on the other. The location of a person on the continuum represents his/her personal health status. This concept as the basis for health promotion considers individual and corporate resources for health, well-being and quality of life as central requirements to prevent health risks and potential illnesses (Antonovsky, 1987, Völker & Kistemann, 2011).

The salutogenic paradigm did not reject the benefits or standing of the pathogenic paradigm, but certainly expanded the understanding of health. Not only did the salutogenic approach provide a groundwork for the concept of health promotion, but also opened up new avenues and perspectives for research in various disciplines. The design discipline was also stimulated by the explicit and implicit reflections of the salutogenic approach. In fact, design researchers who intended to enhance the design practice were already on a similar path of research by focusing on the social and psychological aspects of design.
2.1.3 Understanding Mental Health:

The World Health Organization states that ‘Mental health is not just the absence of mental disorder.’ It is defined as ‘a state of well-being in which every individual realizes his or her own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to her or his community’ (WHO, 2004). On a regular basis, it has always been easier to define mental illness than defining mental health. Mental illness is defined as “collectively all diagnosable mental disorders” or “health conditions that are characterized by alterations in thinking, mood, or behavior (or some combination thereof) associated with distress and/or impaired functioning” (USDHHS, 1999).

But more recently, scholars have recognized that mental health goes beyond the mere absence of mental illness (Halpern, 1995). Not being diagnosed with a mental disorder can no longer be an indicator of good mental health. Even on a day to day basis, some people are mentally healthier than others. The ability to enjoy life, to bounce back from adversity and to strike a balance in life are just among some of the characteristics of positive mental health (Holmes, 2010).

Various factors apart from the absence of mental disorders determine the level of health of a person at any given point of time. These range from social, psychological to biological factors (Halpern, 1995). The Center for Disease Control and Prevention
suggests three main indicators of mental health, namely emotional well-being, psychological well-being and social well-being (www.cdc.gov/mentalhealth/basics.htm). Emotional well-being encompasses perceived life satisfaction, happiness, cheerfulness and peacefulness. Psychological well-being takes account of self-acceptance, personal growth including openness to new experiences, optimism, hopefulness, purpose in life, control of one’s environment, spirituality, self-direction, and positive relationships. And social well-being deals with social acceptance, beliefs in the potential of people and society as a whole, personal self-worth and usefulness to society, sense of community (www.cdc.gov/mentalhealth/basics.htm).

2.1.3.1 Physical and Mental Health Interrelationships:

Mental health is indistinguishably linked to physical health. In the past years, mental health and mental illness has only been looked through wide-angled lens just like the mainstream of public health that takes a broad view of health and illness. But as the field has matured, it has begun to respond to identifying interests and concerns about disease prevention and health promotion (Mental Health: A Report of the Surgeon General, 1999).

A look at the physiological effects of stress gives us an idea of this mental/physical health interconnection (Figure 3). Research suggests that mental health or mental illness in the
form of chronic depression, stress and anxiety is connected to the risk of heart and vascular disease, diabetes, respiratory illness, cancer, and obesity (WHO, 2004). The key findings of American Psychological Association’s ‘Stress in America 2010’ report are consistent with this. The findings from this report also suggest a relationship between stress and obesity in children, often leading from issues like having difficulty falling asleep, headaches, feeling angry, eating too much or too little (Stress in America, 2010).

![Effects of Stress on Long Term Health](Figure created by author based on APA's “Stress effects on Body,” n.d.)

Figure 3: Health outcomes of Chronic Stress

(Figure created by author based on APA’s “Stress effects on Body,” n.d.)
Most forms of mental illness, including the minor neuroses and psychological distress are strongly associated with a number of social variables including low socio-economic status, unemployment and impoverished social networks (Halpern, 1995). Stress arising from perceptions of the residential environments (including police protection, personal safety, cleanliness and noise levels) have been found to be associated with very low birth weight outcomes in African American mothers even after controlling for maternal behaviors such as alcohol use and smoking (Collins et al., 1998). According to World Health Organization, depression, characterized by sustained sadness and loss of interest along with psychological, behavioral and physical symptoms, has been ranked as the leading cause of disability worldwide. Of all the years of life lost because of disability, 23% is caused by mental and substance use (WHO, 2014).

2.1.3.2 Urban Stress as a Determinant of Mental Health:

There has been no definition of stress that everyone accepts. Therefore, it is difficult to measure stress if there is no agreement on what the definition of stress should be (Jones & Bright, 2001). The most common is, ‘physical, mental, or emotional strain or tension’. Another popular definition of stress is, ‘a condition or feeling experienced when a person perceives that demands exceed the personal and social resources the individual is able to mobilize’ (“Daily Life,” n.d.; Jones & Bright, 2001).
Though the term ‘stress’ is generally used to refer to the negative experiences that leave us feeling overwhelmed, stress is nothing but a reaction to a changing and demanding environment. Stress in actuality describes our capacity of handling change rather than how it makes us feel (good or bad) (Aitken, 1975). Stress is not always negative, rather simply the human body’s built-in, automatic mechanism that heightens our perceptions and awareness during uncertain circumstances, preparing our body to react to threats against our perceived sense of safety (Jones & Bright, 2001). Temporary stress can be beneficial by giving us the energy and drive to get through certain unknown situations (like working towards a deadline, moving out of harm’s way or the thrill of experiencing a rollercoaster) (Jones & Bright, 2001)

Unfortunately, societal and cultural pressures like the reliance on automobile transportation, the dwindling minutes of physical education at schools, and the rise in hours of computer and television entertainment are contributing to a more sedentary lifestyle that could have significant impacts on physiological and psychological relationships. The pressures of modern living in cities are precursors to increasing number of problems that we face today including chronic illness, social stress, and larger social disparity. Urban stressors in general tend to affect the mental well-being of the residents. Nowadays, stress is an important public health concern that is related to mental health problems such as burnout syndrome as well as cardiovascular,
gastroenterological, immunological and neurological diseases (Nilsson, Sangster, & Konijnendijk, 2011).

Urban living is a relatively new concept in human history, but it has grown by leaps and bounds (Brookshire, 2011). Currently, more than half the world’s population lives in cities, and urbanization in developing nations will continue to increase that number. Habitat (2001) states that about 75% of the population in developed countries presently lives in dense urban areas (as cited in Van den Berg, Hartig, & Staats, 2007). Theoretically, cities offer many opportunities such as reduction in car use, increase in resource efficiency, accessibility, and economic viability, better sanitation, nutrition, health care, and so on (van den Berg et al., 2007). However, the reality is still far from the safe, clean and livable environments. Living in cities comes with its downsides of increased risk for chronic illness, increased social stress, larger social disparity, a greater divide between the rich and the poor.

In today’s modern urbanized societies, acute and chronic stress are recognized as an increasing problem and a cause for long-term effects on health (McEwen, 1998; Sluiter, Frings-Dresen, Meijman, & van der Beek, 2000). Research shows that crowding, fear of crime and noise from traffic, have all been linked to aggression and violence (Kuo & Sullivan, 2001). S. Kaplan (1995) noted that many settings, stimuli, and tasks in modern life such as traffic, phones, conversations, problems at work, and complex decisions
have information processing demands and draw on the capacity to deliberately direct attention or pay attention. They all lead to mental fatigue, a state characterized by inattentiveness, irritability, and impulsivity (Kuo & Sullivan, 2001).

Center for Disease Control and Prevention (2014) affirms that people report 14 or more days of poor mental health in the past 30 days when asked to describe their mental condition that includes experience of stress, depression and problems with emotions (Center for Behavioral Health Statistics and Quality, 2015). The American Psychological Association’s ‘Stress in America 2010’ survey paints a picture of an overstressed nation. It suggests that one third of the population of the United States is experiencing extreme levels of negative stress (Stress in America, 2010). On a scale of 1-10, where 1 indicates none or very little stress and 10 indicates high level of stress, the survey finding report that most Americans live with a moderate (4-7 on a scale of 1-10) or high (8-10 on a scale of 1-10) levels of stress and are aware that this is unhealthy (Stress in America, 2010).

According to National Institute of Mental Health, 18.5% of the 43.6 million adults in the United States, that is approximately 1 in 5 adults, experience mental illness in a given year. Approximately 21.5% of youth aged 13-18 years and 13% of children aged 8-15 years experience a severe mental disorder at some point during their lives (“Mental Health By the Numbers,” 2014). City dwellers are prone to 21% higher risk for anxiety...
disorders and 39% higher risk of mood disorders. The frequency of schizophrenia is strongly increased in people born and raised in cities and there are higher numbers of suicide cases with underlying mental illness among urban residents (Lederbogen et al., 2011).

Overall, these facts suggest that mental ill-health caused by stress is now becoming one of the world’s most serious public health issues, especially for those living in urban environments. Stress control is a vital issue in maintaining good health and it is important to prevent stress-related disorders in urbanized societies. To manage stress, doctors recommend a strategy of removing oneself from the stressful situation (both mentally and physically) while trying relaxation techniques, such as gardening or visiting a favorite place, and lifestyle changes of diet and exercise. Physical exercise also has significant positive outcomes on mental health and may help in stress reduction and relieve symptoms of depression through two mechanisms: increasing endorphins (hormones that reduce pain and produce a ‘feel good’ effect) and/or keeping the stress response system in shape through better communication between the body’s neurological, physiological, and muscular systems (Dishman & Sothmann, 2005).

The immediate interface between person and his or her environment is the process of perception (Williams, 1994). Physical surroundings effect the human psyche through their direct sensory effects. Both built and natural environments influence perception
and have direct and indirect effects on mental health of people. It is therefore crucial to study the environment to identify and prevent ways in which the environment can adversely affect mental health (Williams, 1994).

2.1.3.3 **Environmental Impacts on Mental Health:**

As presented above, mental health can be seen as a sliding scale with disease on one end, and an optimal condition on the other. Most people sit somewhere in between, hopefully closer to the optimum end. Life events and other experience in life tip that scale towards one end or the other. Many of these events occur within our every-day environments. The environment surrounding us has the possibility of pushing us in either direction of the scale. It can either help enhance health or deteriorate it. The most common misconception associated with mental illness is that it is either genetic or is an internal issue that the person can change themselves. However, there is a possibility that the solution to dealing with some common mental health issues lies within our everyday social and physical environments. The impact that the built and natural environment has on our mental health is tangible (Halpern, 1995) and increasing number of researchers are examining the ways in which this occurs.

The alarming rates of mental illness have drawn more attention towards research and interventions required to improve the mental health of the people. In the recent years, the public health community has become increasingly aware of the health impacts that
the design of the built environment can have on the health and well-being of people. This growing awareness especially in research and design practices emphasize the significance of the built and the natural on the health outcomes (Hansmann, Hug and Seeland, 2007). Researchers in design and mental health areas believe that the design or urban settings can affect our mental health both directly and indirectly. Well-designed environments can influence our mood positively, while monotonous and badly proportioned environments can influence us negatively by creating sensory deprivation and symptoms of mental-ill health. Meanwhile, urban spaces set the stage for social interaction, thus influencing the social well-being of people (Monrad, 2015). The design of urban spaces can considerably influence our patterns of behavior and stress levels. In addition, lifestyles characterized by both, the anonymity of city life in a high-rise and the isolation of automobile-centric sub-urban life can create heavy tolls on urban residents (Ellard, 2015).

Studies indicate that living in an area that has more socioeconomic deprivation has been linked with a higher prevalence of anxiety and depression (Fone et al., 2007), an increased risk of incident depression (Galea et al., 2007), and a greater likelihood of admission to psychiatric hospital, independently of individual-level socioeconomic factors (Sundquist & Ahlen, 2006). Furthermore, data on perception of neighborhood and mental health indicates that disorder and violence in neighborhoods is associated with more anger, depression, and anxiety (Gary, Stark, & LaVeist, 2007; Schieman &
Meersman, 2004), that poorer quality of the built environment is associated with higher levels of depressive symptoms (Galea et al., 2005; Kubzansky et al., 2005), and that undesirable neighborhood characteristics (i.e., trash, vacant housing, crime) predicted more depressive symptoms (Gary, Stark, & LaVeist, 2007; Latkin & Curry, 2003).

2.2 Healing and Therapeutic Environments:

Understanding the concept of health and healing leads us to explore the settings and environments where healing occurs and health is fostered. It is through the notion of improvement that the term ‘therapeutic’ has gained popularity. The common definition of the term ‘therapy’ is ‘which heals (or makes whole)’ (Canter & Canter, 1979). This term can be linked back to the mid 19th century Latin word ‘therapia’ and the Greek word ‘therapeia’ which both refer to ‘healing.’ The Greek word ‘therapeuein’ means ‘to treat medically or to take care of.’

‘Environments for Therapy’ were originally referred to places where therapy or healing occurs, that is, places that encapsulated therapeutic process. Thus medical facilities were initially referred to therapeutic settings (Canter & Canter, 1979). However, John Cumming (1964), Maxwell Jones (1962) and others suggested that environment is (or ought to be) the major therapeutic agent in any given therapeutic situation (Canter & Canter, 1979). Therefore, the term ‘therapeutic environment’ has developed more on lines of being a continuum, with one side referring to ‘simply being a place where
healing or therapy occurs with no impact on the process itself’ and the other side referring to ‘the setting itself being therapeutic in nature.’

This study is more interested in the latter end of this continuum looking at the therapeutic aspects of physical and natural settings. A healing environment promotes well-being, facilitates the delivery of treatment or therapy, and supports the relationships necessary to effect healing (Duross, 2009). Throughout history, landscapes have been bestowed with therapeutic powers. Nature and health were interwoven to form healing landscapes. Below is some evidence from history that underlines the description of ‘therapeutic landscape’ as settings with enduring reputation for achieving physical, mental and spiritual healing’ (Gesler, 1993).

2.2.1 Evolution of Green Spaces as Healing/ Therapeutic Environments:

Historically, healing environments have been places designed for the restoration of the mind, soul and body (Tyson, 1998). It is therefore essential to look back to understand how associations between landscape and health have been described, conceptualized and explained in the past. Right from the beginning, the role of landscape has been considered in salutogenic context and not simply as a therapeutic place for those who are unwell (Ward Thompson, 2011). Gardens, landscapes and natural settings with miniature lakes and meadows have always been described as places where people take refuge and find comfort during hard times as well as places where the body and mind
can both heal (Ottosson and Grahn 2008). The belief was that contact with the natural environment, in any form, be it just through viewing landscapes or actually being present in the natural settings, ameliorates stress and benefits humans’ psychological well-being in general. This has been evident as far back as the earliest documented histories of Persia, Greece and China (Velarde et al. 2007, as cited by Townsend Mardie; Weerasuriya Rona, 2010).

The word ‘paradise’, a heavenly garden (the Biblical garden of Eden) descends from the old Persian word pairi (around) daeza (wall brick or shape), which was composed in one-word meaning enclosed garden or compound or orchard. This word is closely associated with the ideal landscape (the landscape of life) present in numerous cultures and religions as mentioned in the earliest of records (Hobhouse, 2004). A rooted characteristic in the descriptions of paradise throughout history is the wholesome and healthy nature of gardens, supporting human beings in every way, providing delight to every sense. The narratives of gardens go beyond portrayals of landscapes as places essential for all aspects of human health and well-being providing physical nourishment of food and water (Ward Thompson, 2011).

A Greek version of the ideal garden of afterlife was described as the Happy Isles or the Elysian Fields. Ancient Greek texts describe the ideal landscape as a setting for a range of activities that might equally be prescribed for healthy living today, from running and
sport to dance, singing and other artistic or spiritual activities (Kline, 2002; Ward Thompson 2011). While these were descriptions of legendary and idealized landscapes, the important cultural sites in ancient Greece were also chosen with the landscape setting as a primary criterion. Sanctuaries and other healing temples were sacred sites away from the city but there is evidence that urban environments in ancient Greece were also chosen with nature and aesthetics in mind. The importance of the landscape, and sacred groves and springs within it, was recognized for the habitations of urban dwellers (Ward Thompson, 2011).

The history of gardens dates back to the ancient Egyptian villa gardens and the Persian walled gardens of Mesopotamia that were established to maintain human contact with nature (Ulrich and Parsons, 1992, as cited in Morris, 2003). History portrays that Egyptian physicians advised disturbed patients to walk in gardens. In the early nineteenth-century hospitals in Europe encouraged patients to be involved in the planting, caring and harvesting of crops in institutional farms (Nebbe 2006). The earliest hospitals in Europe were situated in monasteries which typically included cloistered gardens, providing ‘relief to the ill’ (Velarde et al. 2007).

The concepts of ‘rus in urbe’ or ‘country in the city’ were recognized in America in the 1680s, when William Penn planned the ‘Greene Countrie Towne’ of Philadelphia, with its four, green squares structuring the urban form, and they were promoted in the early
nineteenth century through the creation of ‘rural’ cemeteries such as Mount Auburn Cemetery in Cambridge. But the development of the larger urban park was inspired by the example of European cities, whose parks were universally acknowledged as a means of improving the health, as well as the social welfare and moral refinement of their citizens (Ward Thompson, 1998; Ward Thompson, 2011). Later, in the 1860s/1870s, Frederick Law Olmsted, a US landscape architect, was convinced that visual contact with nature was beneficial to the emotional and physiological health of city dwellers. Olmsted's theories regarding the healthful, restorative effects of nature in the urban environment were a major influence on the City Beautiful movement and had a widespread effect on the design of parks and urban landscaping (Ulrich and Parsons, 1992). The belief that contact with nature fosters psychological wellbeing and reduces the stress of urban living seems to date back to urbanization itself (Ulrich and Parsons, 1992; Ulrich, 1993).

2.2.2 Contemporary Urban Parks as Healing / Therapeutic Environments:

The importance of environment on human health is not a new concept. In particular, the role of natural environment as a key determinant of health is incontestable. As presented in the earlier sections, many cultures have accentuated the role that nature plays in human well-being through science, philosophy, poetry, and religion for a very long time. Scholars across various disciplines have studied the ways in which the built and natural environments shape the health and well-being of the people (Bratman,
Hamilton, & Daily, 2012). Nature advocates also have presented parks and other green environments as assets playing an essential role in human health.

Gardens, landscapes and natural settings with miniature lakes and meadows have always been described as places where people take refuge and find comfort during hard times as well as places where the body and mind can both heal (Ottosson and Grahn 2008). But today, the world is becoming more urban. As the population expands in the coming decades, this will only become more so.

Living in cities involves an extraordinary disengagement of humans from the natural environment that is likely to be detrimental to health and well-being. In today’s urbanized society, the prevailing problems faced by the urban dwellers have led to growing need for communal spaces within the urban environment. Urban parks may be one of the only means of accessing nature for most people living in urban areas. Urban parks are thus becoming increasingly important as more people inhabit urban areas. Many new urbanites live in high-rise and small square-footage condos or other types of housing units. As a result, they look to the city to provide many of the features that most suburban house-owners take for granted. Thus, parks are now not limited to being civic frills but have become urban necessities. Urban life styles and overall urban stressors are now motivating people to look for greener spaces in the neighborhoods.
Urban parks, that were once considered as the simple aesthetic addition to an urban environment in terms of look and feel, are able to produce measurable effects on our mental health (Ellard, 2015). In the past, public spaces with natural landscapes were generally included in settings wherever they could be afforded and made to work. But now, the entire urban landscape, irrespective of the scale, are being dramatically transformed through careful planning. We can no longer think of city’s green spaces as aesthetic bauble or as the afterthought of city planning. Instead, urban parks and parklets are now one of the most important elements of any city’s planning as they not only protect the essential systems of life and biodiversity, but are also a fundamental setting for health promotion and creation of well-being among urban residents. Figure 4 graphically illustrates the benefits of urban parks and design characteristics of parks that influence health.

![Figure 4: Benefits of Urban Parks](image-url)
2.2.3 Restorative/ Therapeutic Attributes of Urban Parks:

This section provides a range of insights on the psychological background of landscape perception, the technical considerations in urban park design and identifies specific attributes of urban parks that are mostly likely to influence perception, preference and restorative responses.

Back in 1975, Appleton questioned ‘what is it about the landscape that we like and why do we like it?’ (Appleton, 1975). Since then, researchers have tried to explore the components of the natural environments and how they influence human health and behavior in a number of ways. At present, it is well established that the experience of nature produces an array of positive benefits to physical and mental well-being. Much less is still known about the specific attributes of green space which produce these effects (Hunter & Askarinejad, 2015).

The relationship between man and his experience of the natural environment was well described by Appleton (1975) as:

“If the aesthetic enjoyment of landscape is based on behavioral relationships between the observer and his visible environment, it is expected that places will vary in their capacity of simulating aesthetic response, and that this variation will depend partly on the intrinsic properties of these places and partly on the behavior mechanisms which govern these relationships.”
Though ‘perception’ refers to a holistic experience of a space with all senses, very often it is reduced to the visual aspects (Nijhuis, Lammeren, & van der Hoeven, 2011). This is determined by the ‘range’ of our senses. Finnish geographer, Johannes Gabriel Granö, categorized landscapes based on the distance in 1929. ‘Nahsicht’ is what can be experienced with all our senses while ‘Fernsicht’ is what we can experience only visually (Nijhuis et al., 2011). When describing characteristics of landscapes, Appleton (1975) points out:

“The most striking characteristics of places derive from the rocks that which underlie them, the presence or absence of water and the form in which it occurs, the cover of vegetation, the climatic conditions and the intervention of man.”

However, researchers most often argue that the identifying characteristics of any rural, urban or natural environment, which to a large extend are built upon visual perception, are key determinants of behavior and preference. Gibson suggested that people’s visual perception of the environment has a significant influence on their behavior (Gibson, 1979). Similarly, Bronfenbrenner (1975) believed that what matters for behaviors and development is the environment as it is perceived rather than as it may exist in ‘objective’ reality. This concept addresses the need to examine different user groups in different settings and also how different physical characteristics influence behaviors. Specifically, for this study, it is important to examine the design characteristics of urban parks that influence people’s perception of the parks consequently influencing the stress levels of the people experiencing the parks.
2.2.3.1 Interpreting the Park Environments:

Literature from the fields of architecture, urban design and landscape design provide conceptual models for understanding built and natural environments and offer valuable lessons in the conceptualization of urban park environment.

In Architecture literature, space is defined by both the objects surrounding it or objects within it. Ching (2007) suggests that basic elements of space can be classified into horizontal and vertical elements, where horizontal planes create different kind of spaces by elevation or depression and vertical planes or vertical elements separate or establish spaces and provide sense of enclosures (Zhai, 2014). This framework also extends into the outdoor environment. Landform comprising of lawns, soil, pathways, pavements, fields, etc. work as horizontal spatial elements to create various spaces while trees, bushes, cliffs, etc., serve as vertical elements to define the space and prove sense of enclosure (Ching, 2007; Zhai 2014). This framework allows for more abstract interpretation of the outdoor natural environment from a spatial perspective.

In Urban Design literature, Lynch (1960), argues that people urban situations orient themselves by means of mental maps and emphasized on people’s perception of environment. He proposed that these mental maps consist of five elements: (1) paths: routes along which people move throughout the city; (2) edges: boundaries and breaks in continuity; (3) districts: areas characterized by common characteristics;
(4) **nodes**: strategic focus points for orientation like squares and junctions; and

(5) **landmarks**: external points of orientation, usually an easily identifiable physical object in the urban landscape. This framework can also be applied to urban parks as these five elements support way-finding and make the parks more comprehensible and useful.

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**Figure 5: Conceptual Models for understanding Built and Natural Environments**

In Landscape Design, the principles of design define the meaning of space generated by the special arrangement of the natural elements (Bell, 1993). Visual qualities of the elements of design, including line, form, color, texture, and visual weight generate the spatial composition of the natural environment and impart sense of unity, scale, balance, simplicity, variety, emphasis, and sequence within the natural environment features to create an aesthetically pleasing landscape.
2.2.3.2 Exploring the Visual Elements in Urban Parks:

Visual perception studies describe an imperative difference between the ‘physiology of perception’ (the senses) and the ‘psychology of perception’ (the brain) (Jacobs, 2006; Bell, 1996; Nijhuis et al., 2011). For this study, it is important to look at the psychology of perception that refers to two distinct processes. First is the basically unconscious processing of the sensory information and second is the more conscious experience of analyzing and interpreting the information in the field of vision (Jacobs, 2006; Nijhuis et al., 2011). Both these complex processes include pattern recognition (shape, size, spatial arrangement) and color discrimination (Nijhuis et al., 2011).

While there are a number of theories that postulate why nature is restorative (Kaplan, 1995; Berman et al., 2014), lack of translational research makes it difficult to design urban parks to obtain maximum restorative benefit. Researchers suggest that environmental scenes have collaborative properties and can cause a viewer to pay attention, engage, look for further information and compare (Berlyne, 1970). Berlyne (1970) also predicted that when all of the collaborative properties occur in moderation, the viewer can perceive the setting as more beautiful and will in turn lead to more restoration (Hunter & Askarinejad, 2015).

Landscape quality assessment attempts to determine the relative location of different landscapes along a dimension of scenic beauty (Daniel & Vining, 1983; Zhai, 2014).
This process also helps identify landscapes and elements within the landscape that are preferred by people (Kaplan, 1989). Researchers claim that an individual’s past experiences and standards for attraction can influence the evaluation of scenic beauty (Arthur, et al., 1977; Zhai, 2014). Kaplan’s understanding-and-exploration framework highlights how different spatial arrangements within the natural environment influences people’s preference and meaning of the space (Kaplan et al., 1998) and provides insights into the design and management of the natural environment.

<table>
<thead>
<tr>
<th>Availability of Information</th>
<th>Need</th>
</tr>
</thead>
<tbody>
<tr>
<td>2D (Immediate)</td>
<td>UNDERSTANDING</td>
</tr>
<tr>
<td></td>
<td>Coherence</td>
</tr>
<tr>
<td></td>
<td>Direct perception of the elements in the scene in terms of their numbers, grouping and placement</td>
</tr>
<tr>
<td>3D (Inferred)</td>
<td>Legibility</td>
</tr>
<tr>
<td></td>
<td>Inference of the third dimension, where an individual imagines himself/herself in the scene</td>
</tr>
</tbody>
</table>

*Figure 6: Kaplan’s Understanding-and-Exploration Preference Matrix*

Humans interpret the environment based on the affordance of the environment or the possible functions in it (Kaplan et al., 1998). Kaplan et al. (1998) suggest that even small amounts of coherence, legibility, complexity or mystery can make a considerable difference in how comfortable people feel in an environment. In 1989, Kaplan & Kaplan proposed the nature preference matrix that concerns with the two basic informational
needs- understanding and exploration, and with the dimension that considers how readily available the information is (Kaplan & Kaplan, 1989). Visual landscape attributes like spaciousness and related indicators, such as degree of openness, density, nature of spatial boundaries are important elements in landscape perception and preference (Nijhuis et al., 2011).

2.2.3.3 Identification of Park Attributes linked with Restoration:

Hunter and Askarinejad (2015) in their recent pioneering study, attempt to quantify the specific elements of design within urban green spaces that have maximum restoration potential by using triangulation process invoking environmental psychology theories, principles of design and empirical research on the role of specific physical attributes of the environment in preference or restoration responses. They provide a list of physical attributes, defining aspects of special structure and environmental content found to be the most relevant to perceptions involved with preference and restoration.

Comparison of all environmental psychology theories revealed ten structure-content properties of greatest relevance to preference and restoration responses (Hunter & Askarinejad, 2015) (Figure 7).

(1) Naturalness, defined as any type of nature content (presence of biota, land, water or sky), was a unanimous predictor for preference and/or restoration.
(2) **Complexity**, defined as information richness of a scene deriving from diversity in its physical structure and physical content.

(3) **Structural Coherence** described as degree of unity and visual order achieved through patterning or linkage of scene components (e.g., a linear succession of tree trunks or canopies)

(4) **Structural Form**, where a scene appears as an organized whole that is more than the sum of its parts,
(5) *Depth Cues*, that help understand the proportional relation and size of objects in a scene,

(6) *Openness*, defined as a position along a continuum from physical or visual spaciousness to full enclosure.

(7) *Information Gathering Support* includes features of the environment that support the ability to learn more about a setting, often by moving deeper into it.

(8) *Access*, defined as having sufficient and readily understood information that is useful for navigation through an environment.

(9) *Safety*, based the presence of environmental form and features that offer protection (or not), especially while gathering information and

(10) *Engagement*, based on the presence of something physical that holds the attention.

Nine of ten theories predict naturalness as foundational to preference for and/or restoration from the landscape (Hunter and Askarinejad, 2015). This study further intensifies the need to explore the specific design attributes in the nature environment that can enhance experience and support restoration.

### 2.3 Theoretical Approaches to Healing/Therapeutic Environments:

There are number of theories related to contact with nature and human well-being derived from a range of disciplines, in particular psychology. Some of the most popular theories in this area include the biophilia hypothesis, attention restoration theory and
stress reduction theory. Few other, not so popular, theories in this discipline include the relaxation response, environmental self-regulation hypothesis, Maslow’s hierarchy of needs, and the bio-ecological model.

Two prominent theoretical perspectives in the literature that consider the relationship between green spaces and mental health that are most relevant to the purpose of this study are:

   a) Attention Restoration Theory (ART) and
   b) Stress Reduction Theory (SRT)

These two theories overlap in many respects, focusing on different mechanisms that account for environmental benefits and human well-being.

2.3.1 Attention Restoration Theory (ART):

Attention Restoration Theory (ART) formulated by Rachel Kaplan and Stephen Kaplan in 1995 is based on the work of William James. James (1962) acknowledged that humans have two types of attention: voluntary and involuntary. Voluntary attention is the type of attention used when a task requires deliberate and sustained attention while involuntary attention does not require an effort (James 1962, as cited in Kaplan, 1995). Building on this work, Kaplan and Kaplan (1989) describe attention fatigue as a process that occurs during the performance of cognitive tasks which require mental effort,
prolonged use of conscious focus and active inhibition of irrelevant information and
distracting stimuli.

In their book ‘The Experience of Nature’, Kaplan and Kaplan (1989) explain the
relationship between people and the natural environment and develop the concept of
restorative environment in which mental energies are recovered and effectiveness is
enhanced (Morris, 2003). The Attention Restoration Theory proposes that restorative
environments assist well-being by restoring previously depleted cognitive resources,
specifically, directed attention.

Kaplan and Kaplan (1989) believe that the natural environment contributes to the
restorative process by capturing involuntary attention in four ways. First, the natural
environment provides retreat from routine activities and thoughts. This provides a sense
of ‘being away’. This sense of escape is associated with natural environment in the
vicinity within urban areas, as well as with more distant areas in close proximity to the
sea, mountains, lakes, streams or forests (Kaplan, 1995). Second, the natural
environment offers ‘soft fascination’ as it is comprised of natural elements such as
clouds, waves, snow patterns, movement of leaves in the wind, etc., that effortlessly
capture interest- driven attention while providing sufficient opportunity for individuals
to relax and reflect (Kaplan, 1995; Kaplan & Kaplan, 1989; Morris, 2003). Third, the
natural environment has ‘extent’, i.e., it is rich and comprised of coherently ordered
elements that can provide a depth of experience and substantial scope to engage an individual’s mind (Kaplan, 1995). And fourth, the natural environment supports an individual’s purposes and inclinations and provides ‘compatibility’ in terms of human desires and the setting in which they occur (Kaplan, 1995; Morris, 2003).

Kaplan and Kaplan (1995) suggest that for an environment to be restorative, it must contain these four features. They also focus on what nature does, for whom, and under what circumstances. (Kaplan & Kaplan, 1989).

2.3.2 **Stress Reduction Theory (SRT):**

While the Attention Restoration Theory (ART) focuses on cognitive processes, the Stress Reduction Theory (SRT) is more focused on emotional and physiological processes. The stress reduction theory provides a more general guideline of what makes an environment restorative and thus opens up opportunities to study restorative effects under a multitude of conditions (Lynnae Twedt, 2013).

Established by Roger Ulrich in 1991, the Stress Reduction Theory (SRT) is closely related to the Biophilia Hypothesis and suggests that natural environments promote recovery from stress while urban built environments tend to hinder the same process. This psycho-evolutionary theory is built on the belief that view of nature or a visit to a natural environment after a stressful situation, involving challenge or threat, promotes
physiological recovery and relaxation (Ulrich, 1983; Hartig, Evans, Jamner, Davis, & Gärling, 2003).

In the context of this theory, Dr. Roger Ulrich defines stress as a set of psychological and physiological responses to any situation that challenges or threatens well-being (Baum et al., 1985; Ulrich et al., 1991). Per this theory, the body responds to stress psychologically by means of cognitive evaluation of the situation and emotions such as fear, anger, and sadness. The body also provides coping responses to stress, such as the physiological reactions including changes in cardiovascular, skeletomuscular and neuroendocrine activity in the body (Ulrich et al., 1991). Researchers claim that these changes in the body consume energy and if continued for long periods, they contribute to fatigue (Ulrich et al., 1991).

Dr. Ulrich (1983) advocates that the healing power of nature lies in an unconscious, autonomic response to natural elements that can occur without recognition and most noticeably in individuals who have been stressed before the experience. He proposes that particular qualities and contents in the nature scene can support psychophysiological stress recovery (Hartig et al., 2003). Psycho-evolutionary theorists and researchers also state that nature views with moderate depth, moderate complexity, presence of a focal point and natural contents such as vegetation and water can evoke positive emotions, sustain unvigilant attention, constrain negative thoughts and consequently lead the autonomic arousal to moderate levels (Hartig et al., 2003). The
The underlying mechanism for stress reduction in natural environments is that they do not require large amount of information to be processed, thus helping an individual’s arousal (stress) level to reduce by spending time in such natural settings (Ulrich 1979). It is assumed that while urban environments require more mental resources to process because they are not a human’s native environment, humans may be more attuned to pay attention to natural environments, since this is where we evolved (Ulrich et al., 1991).

Stress typically occurs when an individual is faced with a challenging or threatening situation or when associated with negative effect. This leads to inability to focus and increased physiological arousal (e.g., increased heart rate and blood pressure). However, researchers claim that certain environments can improve well-being by reducing stress (Ulrich, 1991). An environment that can reduces stress should lead to a positive change and a decrease in physiological arousal, which may improve health outcomes. Stimulating urban environments, especially those with high levels of visual complexity, noise, intensity and movement, can overwhelm the senses and affect people negatively by producing excessively high, stressful and fatiguing levels of psychological and physiological ‘excitement’ and ‘arousal’. On the other hand, natural environments, dominated by vegetation and water features, tend to be lower in intensity and complexity. These natural environments have a comparatively positive, stress-reducing effects on people (Ulrich & Parsons, 1992).
In the meanwhile, a number of research studies have tested the validity of this Stress Reduction Theory. Some of the earliest studies accounting for this theory were conducted by Roger Ulrich and his colleagues (Ulrich, 1979; Ulrich, 1981). His initial studies found that immediately subsequent to a required one-hour course examination, undergraduate students who viewed photographic scenes of nature (vs. urban built scenes) had a rapid improvement in positive mental outlook and a decline in reported fear and arousal (Ulrich, 1979). In 1981, Dr. Ulrich conducted another study with healthy unstressed participants in normal arousal state using an electroencephalograph (EEG) apparatus to evaluate brain wave activity while the participants watched the photographic scenes of either a nature image with water, a nature image with vegetation or urban environments without water or vegetation. The effects of the images were physiologically measured on alpha-amplitude, heart rate, and emotional states as valid indicators of the arousal or activity state of the participants. The results confirmed that nature images, both including water and vegetation, held attention and interest of the participants more effectively than the urban scenes. They also had more positive influence on psychophysiological state of the participant (Ulrich, 1981). In 1984, Ulrich and his colleagues found that having a window view of nature, as opposed to the brick wall of another building, was associated with shorter hospital stays, better rapport with nursing staff, and fewer pain medications, for patients recovering from gall-bladder surgery (Ulrich, 1984).
Utilizing the psycho-evolutionary stress-reduction theory, other studies conducted also presented the restorative influences of nature, such as more positively-toned emotional state, as well as positive changes in physiological activity levels that are accompanied by sustained attention/intake (Ulrich et al., 1991). Findings indicated that recovery from a stressful event is faster and more complete when individuals are exposed to natural versus urban environments.

2.3.3 Theoretical Approaches: Brief Summary

As Hartig and Evans (1993) stated, theories of the therapeutic effects of nature have been dominated by conflicting positions, one emphasizing stress reduction (Ulrich, 1984; Ulrich et al., 1991) and the other concerning the recovery of the capacity to focus attention (Kaplan & Kaplan, 1989). Both Attention Restoration Theory (ART) and Stress Reduction Theory (SRT) complement each other in regard to the antecedent condition from which the person becomes restored. Both theories focus on the restorative effects of natural environments. ART is mostly appraised within the general population, SRT mostly ascends from research within healthcare settings, as these facilities are largely stressful and tend to threaten well-being in several ways (Parsons, 1991).

There are also overlaps and similarities between these two branches within the scope of environmental psychology (Jiang, 2015). In terms of physiological measures of stress,
elevated arousal and negative effect can occur in absence of directed attention fatigue. Contrarily, elevated arousal or negative affect need not always accompany attentional fatigue (Kaplan, 1995). Some researchers consider attentional fatigue as an aftereffect of stress while others treat it as a condition that increases susceptibility to stress (Hartig et al., 2003).

Figure 8: Integrated Framework of ART and SRT

Thus, in some cases, each of the precursor conditions may occur in isolation, but in other cases, they may be in a reciprocal relationship or coincidence with each other (Hartig et al., 2003). In 1995, Stephen Kaplan presented an integrative framework (Figure
5) that places both directed attention and stress in the larger context of the human-environment relationships model trying to synthesize two theories (Kaplan, 1995). Two categories of factors leading to stress (i.e., harm and resource inadequacy) that were discussed pointed out that information-processing demands are related to attentional fatigue and stress. The integrative model assumes that ‘insufficient attentional resources will often be an antecedent of stress’. In other words, resource depletion containing insufficient attentional resource, harm and other resource inadequacy can lead to a level of stress (Kaplan, 1995; Jiang, 2015).

2.4 Empirical Findings on How Nature Nurtures:

Researchers from a variety of disciplines have explored the different ways in which the natural environment shapes the health and well-being of the people. The fact that the natural environment is a key determinant of health is incontestable. Associations between landscape and health have been observed for a long time across different cultures and societies (Velarde, Fry, & Tveit, 2007b). The benefits of spending time in nature have been described for many centuries. The belief that contact with nature fosters psychological wellbeing and ameliorate the stress of urban living seems to date back to urbanization itself (Ulrich and Parsons, 1992; Ulrich, 1993).

Within the last 25 years, ways of linking nature and health effects have emerged as a topic of interest in the field of human health. As a result of the mounting technological advances, researchers have generated a plethora of literature to explain the ways in
which natural and other environments have an effect on human health. Most empirical research related to health benefits of nature can be classified into different categories based on their methodological approaches. One category of research studies distinctly measures individuals’ preferences of therapeutic/restorative environments and their perception of restoration. The other category of research studies look at the actual health benefits of contact with nature through different levels of person-nature engagement, including (1) visual contacts with nature, through a window, or seeing a picturesque painting; (2) being present in a natural setting, such as a garden near the residence or an urban park; and (3) active participation and involvement in nature, such as gardening, and physical exercises in a natural environment, also known as green exercise (Pretty, 2004).

The first group of research efforts focus on evaluating how a mere view of or proximity to nature (passive contact with nature) improves well-being, as well as the evaluation of the impact of simple visual cues such as images or videos of nature that influence stress-reduction and well-being, irrespective of the level of immersion within the environment. The second group includes research studies that assess how interactions (active contact) with nature (e.g., walking through a park, sitting in a garden, etc.) affect well-being. Empirical research studies typically include the participants undergoing a cognitive, emotional, or physiological stressor tests in order to deplete resources and ultimately testing what types of environments lead to faster recovery (Lynnae Twedt, 2013).
Figure 9: Benefits of Contact with Nature
2.4.1 View of Nature

Visual connection to landscape is believed to affect human beings in many ways, including aesthetic appreciation, health and well-being (Velarde et al., 2007b). The views from buildings is intrinsically related to the process of visual perception, which deals with the visual stimuli generated by the elements in the view, and is the result of physiological processes based on biological principles inherent to human beings and (Weber, 1995). Visual perception is dominant in comparison to perception through the other senses (hearing, smell, and touch), accounting for over 80% of our sensory input (Porteous, 1996). The previous research has also studied the impact of viewing the natural settings on different population groups (such as children, teenagers and older adults) in various building types, such as housing, offices, schools, hospitals and prisons. (Taylor, Kuo, & Sullivan, 2002; Kweon, Sullivan, & Wiley, 1998). Most of these studies have shown a positive impact of broad and organized views, with the presence of natural elements on people’s well-being and health.

Researchers acknowledged the importance of view of nature in residential setting (view through windows at home) as important for quality of life (Kaplan, 2001). Views that are appealing are likely to be restorative as they draw attention effortlessly and support recovery from directed attentional fatigue. Views through windows have the potential of providing micro-restorative opportunities with minimum or no effort or time. A satisfying nature view from a window can provide the same benefits to mental fatigue as a vacation
in a natural environment (Kaplan, 2001). Kaplan’s study across six different apartment communities in Ann Arbor, Michigan indicated that the window view of a natural scene was a strong factor in affecting well-being and residential satisfaction (Kaplan, 2001). He also found that the specific components of the nature view were associated with specific outcomes. While views of gardens and flowers were important to satisfaction and effective functioning, views of trees emerged more pertinent to the sense of being restored and having one’s directed attention intact. Additionally, being able to view farmland or fields contributed to feeling less distracted (Kaplan, 2001). Kuo and colleagues also demonstrated that viewing green spaces from windows at homes located in the barren urban environment of Chicago resulted in a great difference to people’s lives (Kuo, Bacaicoa, & Sullivan, 1998). The researchers conducted their study at Chicago’s Robert Taylor Homes, where one hundred residents living adjacent to the open space rated computer-simulated images with respect to preference and sense of safety. Tree density, tree placement, and levels of grass maintenance were manipulated in the photo simulations of neighborhood outdoor spaces. The findings of the study indicated that tree placement had little to no effect on the sense of safety, however tree density and grass maintenance largely increased the preference and sense of safety among inner-city neighborhood residents (Kuo et al., 1998).

Research conducted in prison environments suggests that views of nature through cell windows are associated with a lower frequency of stress symptoms in inmates, including
digestive illnesses and headaches, and with fewer sick calls overall by prisoners (Moore, 1981). In another study students who had natural views from their dormitories also showed greater attention capacity (Tenessen and Cimprich, 1995).

In workplace settings, view of nature from an office window has been found to be a not just a matter of preference but also one of health and well-being. Studies indicate that in office settings, individuals sitting in a room with views of trees experienced more rapid declines in diastolic blood pressure, indicating greater stress reduction than persons sitting in a viewless room (Hartig et al., 2003). Windows in workplace help buffer the work stress thus leading to long term benefits. For example, employees with a window view from their desks have shown to have fewer illnesses, feel less exasperated, be more patient and more enthusiastic towards work (Pretty, 2004). When a real view of outside nature is not possible, even pictures of nature scenes seem to confer benefit (Heerwagen and Orians, 1998 as cited by Pretty, 2004). Consistent evidence also points towards a relationship between lack of windows in workplace and job dissatisfaction, feelings of isolation, depression, restriction and tension (Leather, Pyrgas, Beale, & Lawrence, 1998). A study involving 100 white and blue-collar employees in a large organization in Southern Europe found that window views, especially views of natural elements (i.e., trees, vegetation, plants, and foliage), buffered the negative impact of job stress on intention to quit and provided positive effect on general well-being of the employees (Leather et al., 1998). Qualitative studies also revealed that employees dislike working
in windowless offices (Collins, 1975 as cited in S. Jiang, 2015). Kaplan (1993) further investigated the role of nature views from office windows using controlled experiments and found that employees perform better in offices with access to natural window views in comparison to working in a windowless office. Survey studies also revealed that workplace settings with window views of nature received higher scores on job satisfaction and environmental restorativeness. (Kaplan, 1993; Kaplan, 2007). In addition, employees with views of nature reported fewer illnesses and headaches (Kaplan and Kaplan, 1989).

The benefits of window views of nature have also been widely studied in healthcare facilities. Healthcare facilities are believed to be most stressful environments for all those who use it, including the patients, families, friends and healthcare professionals. The classical experimental research comparing window views of nature versus view of a brick wall from the patient’s room in a suburban Pennsylvania hospital found that natural views through windows can foster faster recovery in patients during post-surgery (Ulrich, 1984). This study found that during the recovery phase from cholecystectomy (a gall bladder surgery) patients with a view of nature had significantly shorter duration of stay in the hospital, needed moderate medication and had fewer negative comments in the nurses’ notes (Ulrich, 1984). Another study of Alzheimer patients in five homes found that those in the three with gardens had significantly lower levels of aggression and violence than those in the two with no gardens (Ulrich, 1993). A more recent study in
the healthcare environment involved patients undergoing flexible bronchoscopy (a procedure that involves inserting a fiber-optic tube into the lungs) where eighty patients were randomly assigned to receive either sedation or sedation plus nature. Nature was provided in the form of a mural of a mountain stream through a spring meadow along with a continuous tape of complementary nature sounds (e.g., water in a stream or birds chirping). This study found that patients who had contact with nature views reported significantly better pain control (Diette, Lechtzin, Haponik, Devrotes, & Rubin, 2003). Healthcare professionals, especially nurses are extremely important to the healthcare industry and researchers have also looked into how nature views in healthcare settings can impact nurses’ satisfaction, performance, and job retention.

A survey-based research study conducted in two pediatric hospitals in Atlanta, GA, explored the outcomes of exposure to exterior views from nurse work area on the acute stress and alertness of the nurses. It also examined the duration and content of exterior views from nurse work areas (Pati, Harvey, & Barach, 2008). Researchers found that the association between the view duration, alertness and stress is dependent on the exterior view content (that is, nature view, non-nature view). Results indicated that nurses who had a nature or exterior view, their alertness level, as well as stress condition remained the same or improved. On the other hand, nurses who had no view or were exposed to only non-nature view showed deteriorating alertness levels (Pati et al., 2008). Similarly, another recent study conducted by a group of researchers at Texas A&M University
looked at the design of hospital staff break areas. Researchers found that nurses who had visual and physical access to the outdoor spaces (e.g., balconies or porches) had significantly greater perceived restorative potential, in comparison to nature artwork and indoor plants (Nejati, Shepley, Rodiek, Lee, & Varni, 2016). Nature provided the nurses with a sense of escape from job-related stress and fatigue, as well as an opportunity for positive physical and mental distraction (Nejati et al., 2016). It is evident that window views with nature scenes can reduce work pressure and job related stress for care-givers, hence reduce medical errors and enhance patients’ health outcomes.

2.4.2 Presence in Nature

The second category of studies that look at human-nature relationships deal with incidental exposure to nearby nature while being engaged in other activities. This relationship goes beyond just viewing nature through a window, but rather involves being physically present in the nature and experiencing it in real-time. Numerous researchers have looked at how varying natural settings or natural elements within the everyday environment improve health and quality of life. It is revealed that short-term exposures to restorative environments (micro-restorative events) have important recuperative effects (Bennett, 2011).

Researchers claim that green views from home, plus nearby nature in which children can play, have a positive effect on cognitive functioning of children and their capacity
to think (Pretty, 2004). An empirical study examined children aged 8 to 10 years that lived in small towns in five rural upstate New York communities. This study found that the impact of stress was lower among children with high levels of nearby nature than among those with little nearby nature. The children who were exposed to both indoor and outdoor vegetation were overall less stressed and were also able to recover from stressful events better than those in green-less homes and backyards (Wells & Evans, 2003). More and more researchers are now exploring the previously overlooked impact of school landscapes on student academic performance. Recent studies examining student’s exposure to nature through school campuses discovered that the amount of vegetation on and surrounding campus significantly predicted school-wide student performance (i.e., standardized test scores, graduate rates) (Matsuoka, 2010; Wu et al., 2014; Li & Sullivan, 2016). In a randomized controlled study, researchers reported that students who received nature exposure scored significantly higher on tests of attentional functioning and recovered significantly faster from a stressful experience than their peers who did not receive any nature access or views (Li & Sullivan, 2016). Another group of researchers examined children 7 to 12 years old who were professionally diagnosed with ADHD. These children took 20-minute guided walks through a city park and two other well-kept urban settings, one week apart from each other. After the walk, the children’s concentration was measured using Digit Span Backwards. Results concluded that children with attention deficits concentrated better after walking in a park than after walking in either of two other urban settings. The effect of green was also substantial.
The park setting was also experienced significantly more positively than the other two urban settings (Andrea Faber; Taylor & Kuo, 2009). Taylor et al. (2009) also investigated the relationship between nature near-home and self-discipline among children (i.e., their capacities for concentration, impulse inhibition and delay of gratification). It was observed that for girls growing in the inner-cities, green spaces located immediately outside of their homes was helpful in achieving more effective, self-disciplined lives, whereas for boys, distant green spaces were equally important (Andrea Faber Taylor, Kuo, & Sullivan, 2002).

Researchers suggest that even brief exposure to a natural environment can lead to measurable recovery from stress and mental fatigue, while observing improvements in attention and memory (Hartig et al., 2003; Taylor & Kuo, 2009; Tennessen & Cimprich, 1995). Berman et. al. (2008) conducted a quasi-experimental study to test nature’s influence on the memory of participants. The participants first completed a backward digit span task, then performed a 35-minute test that induced mental fatigue and then were randomly sorted into two groups: one group that walked through an urban setting, and another that walked through an arboretum. Both walks lasted approximately for 50-55 minutes. The participants performed the digit-span backward task again after the walk. The results indicated that the performance on backwards digit-span significantly improved when participants walked in nature, but not when they walked through the downtown. Significant improvements in memory were also noted in a second study in
which groups viewed pictures of natural versus urban scenery (Berman, Jonides, & Kaplan, 2008). A quasi-experimental study by Roe and Aspinall (2011) compared the restorative benefits of walking in urban and rural/natural settings in two groups of adults with good and poor mental health. The results were consistent with a restorative effect of landscape: the rural/natural walk was more advantageous to affective and cognitive restoration in both groups when compared to the results from the urban walk. Also, a significantly larger restorative change from walking in nature was observed in participants that had reported poor health at the onset of the experiment (Roe & Aspinall, 2011).

It is assumed that green spaces may not only affect stress and mental fatigue directly, but may also have indirect effects by serving as a buffer against the health impacts of stressful life events (van den Berg, Maas, Verheij, & Groenewegen, 2010). A few studies have explicitly examined buffering effects of green spaces on various health outcomes. An experimental study of people exposed to different types of roadside corridors found that those who drove through urban-dominated hardscapes were more stressed as compared to those who drove through nature dominated scenes, as measured by the magnitude of the galvanic skin response to a consequent stressor (Parsons, Tassinary, Ulrich, Hebl, & Grossman-Alexander, 1998). Another quantitative study investigated the extent to which the presence of green space can attenuate negative health impacts of stressful life events in a sample of Dutch residents. The researchers not only measured mental health, but
also physical and perceived general health. To understand the influence of distance to green space, the researchers differentiated between green space within one-kilometer radius around home and green space within three-kilometer radius. The results showed that respondents with high amount of green space in a 3-km radius were less affected by the experience of a stressful life event than respondents with a low amount of green space in this radius. A similar pattern was observed for the perceived mental health as well (van den Berg et al., 2010).

While the availability of green spaces has been associated with a wide range of health benefits, including stress reduction, most of the existing evidence has relied on self-reported health indicators. More recently, researchers have turned towards more objective measures to study the benefits of nature in people’s every day, residential settings. An exploratory study by Dr. Catherine Ward et al. (2012) uses salivary cortisol as a biomarker along with self-reports that helped to look for variation in stress levels which may be associated with varying levels of exposure to green spaces. This study was conducted in a Scottish city that is characterized by highly deprived urban population. The results of the study illustrated the relationship between self-reported stress, diurnal patterns of cortisol secretion and the quality of green space in the living environment and found that those residing within areas of greater percentage of green space were more resilient to the negative effects of urban deprivation and the stress-related consequences (Ward et al., 2012). A groups of researchers from the University of Illinois,
Urbana Champaign have also been using salivary cortisol levels and skin conductance levels as indicators of stress while exposing participants to different natural environments. A study conducted by this group focused on understanding the specific dose of nature that helps to reduce stress. In addition, it was observed that changes in men’s physiological stress were significantly associated with varying densities of tree cover. For males, a 6-min exposure to a video with moderate tree cover density evoked about 3 times the stress reduction. The shape of the nature dose–response curve was best described as an inverse U-shaped quadratic curve in which moderate tree cover density elicited greater stress reduction than either low or high levels of tree cover density (Bin Jiang et al., 2014). More recent studies have used hair cortisol concentration (HCC) as novel, non-invasive biomarker of chronic stress and found that stress measured by HCC was higher in areas with less natural environment (Gidlow, Randall, Gillman, Smith, & Jones, 2016).

Recent research efforts are building on the fact that being present in nature can influence mental wellbeing and aid recovery from stress. Technological advancements have now made it possible to create immersive virtual reality environments within laboratory setting and increasing number of researchers are now using that as a means to study specific pathways in which nature influences health and well-being.
2.4.3 Active Engagement with Nature

Active engagement with nature comprises of direct participation in activities in green spaces, such as gardening, exercise, walking, jogging, trekking, etc. This group differs from the second category, as by it very virtue, it implies a voluntary decision to go to or be in a natural environment rather than being incidentally exposed to it while being involved in another activity (Pretty, 2004). Individuals who spend time outdoors, take walks or hikes in nature, exercise in park, are more likely to feel positive, focused, effective and alert (Kaplan, 2001; S. Jiang, 2015). Being active and engaged in natural environments has many psycho-physiological beneficial effects on health (i.e. positive psychological effects that translate into positive physiological effects) (Nettleton, 1992).

While gardening is commonly perceived as a leisure activity, it has always gained some recognition for its healing powers. Private and community gardens provide direct link to nature for many people, and thus are particularly valuable in urban settings. They not only provide food, like vegetables, fruits, herbs, etc. for the poorer urban groups, but also transform vacant land into desirable areas for local people to visit and enjoy (Pretty, 2004). Community gardening also provide an opportunity for mental health patients to engage in work that builds self-esteem and confidence, and for unemployed people to use their time productively in their own community (Pretty, 2004). Gardening and horticulture therapy have shown positive outcomes in patients with dementia or post-traumatic stress symptoms (Detweiler et al., 2012). Gardeners find that gardening
activity, combined with a natural setting, is relaxing and calming (Wolf, Krueger, & Rozance, 2014). Participants of one study considered their community gardens as spaces of retreat within crowded neighborhoods and attributed feelings of lower stress and greater sense of well-being to the gardening experience. Physical and perceived stress levels decreased significantly among older individuals who maintained a community garden plot compared with those who exercised indoors, suggesting benefits of gardening activity for healthy aging (Hawkins, Thirlaway, Backx, & Clayton, 2011; Wolf et al., 2014).

Green exercise is another most common ways in which people engage with nature. Evidence shows that green exercise enhances restorative effects of urban greenery and leads to positive short and long-term health outcomes (Barton & Pretty, 2010). A group of researchers conducted a multi-study analysis to determine the best regime of doses of acute exposure to green exercise that can impact self-esteem and mood. The dose-responses were assessed for exercise intensity and exposure duration. Results indicated that short engagement in green exercise generated large benefits for both intensity and duration (Barton & Pretty, 2010). While the results of this study varied across gender and age, the mentally ill participants showed greatest improvements in self-esteem (Barton & Pretty, 2010). Another study examining the synergistic benefit of green exercise took a quasi-experimental approach. The participant groups were exposed to a sequence of scenes (rural or urban, pleasant or unpleasant) projected on a wall while exercising on
a treadmill. Levels of blood pressure and two psychological measures (self-esteem and mood) indicated that exercise alone significantly reduced blood pressure, increased self-esteem, and had a positive significant effect on 4 of 6 mood measures. Additionally, while both rural and urban pleasant scenes produced a significantly greater positive effect on self-esteem than the exercise-only control, the rural unpleasant scenes had the most dramatic effect, depressing the beneficial effects of exercise on three different measures of mood (Pretty, Peacock, Sellens, & Griffin, 2005). A very recent study looked at the psycho-physiological responses to walking in natural and urban environments. The results of the study found that green (natural) and blue (natural with water) environments were associated with greater restoration experiences, cognitive function improvements and stress reduction (mood and cortisol changes) that persisted at least 30 min after leaving the environment. (Gidlow, Jones, et al., 2016).

Adventure therapists have acknowledged the strong connections that this type of therapeutic relationship holds with the outdoors and the natural world. Adults who participate in wilderness excursions describe “an increased sense of aliveness, well-being, and energy,” and note that the experience helps them make healthier lifestyle choices afterwards (Greenway, 1995). Hartig et al. (1991) explored the restorative benefits of nature through a quasi-experimental study. A group of participants involved in wilderness backpacking and non-wilderness vacation conditions, as well as a control conditions were involved as a part of the study. Results have shown that experiences in
wilderness improved sustained attention, according to the data gathered from self-reports. It also created feelings of peacefulness and provided opportunities for reflection (Hartig, Mang, & Evans, 1991).

As described above, numerous studies have found that as compared to exercising indoors, exercising in natural environments was associated with greater feelings of revitalization, increased energy, and positive engagement, as well as decreased tension, confusion, anger and depression (Bashir, 2012). Keeping these benefits of nature exposure in mind, the concept of ‘park prescription’ is now becoming popular. ‘Park Prescriptions’ is a concept that links the healthcare system and public lands, such as local parks, to create healthier people. While people are getting heavier and more depressed each day due to inactivity and poor diet, more and more local parks are reaching out to their local medical community to work together and offer services that help prevent and treat health problems. It is not surprising that patients can receive a prescription from their doctor to take a walk in the park or exercise in the outdoors to help alleviate their symptoms (Bashir, 2012).

2.5 Summary of Literature Review and Knowledge Gap

Extant empirical studies provide insightful findings regarding restorative benefits of urban parks. Literature uncovers the pressures of modern living in cities that are precursors to increasing number of problems that we face today including chronic illness, social stress,
and larger social disparity. Various conceptual and theoretical perspectives align with the prophecy that while urban environments hinder recuperation and amplify the hassles of everyday life, contact with nature reduces attentional fatigue, mitigates the psychological and physiological correlates of stress and positively impacts one’s ability to cope with difficult life circumstances through a variety of causal factors. Prevailing evidence has only reflected on the broad ‘nature’ versus ‘urban’ dichotomy, examined access and distance from nature in association with stress or focused on restorative benefits of nature within the healthcare facilities where stress is prevalent among all groups of users. Very few empirical studies have explored the precise design characteristics of these natural restorative environments and the ideal amount of green exposure that help people with recovery from daily stress, cope with depression, trigger optimistic mood changes and contribute towards positive experience of the green space thus enhancing overall mental well-being. Studies have also mostly relied on subjective indicators of stress through self-reports as a measurement of stress.

The current study aims at addressing this gap in literature and providing a broader understanding of the design characteristics of urban parks (green spaces in people's everyday urban life) that are associated with stress reduction caused by daily urban life stressors. This study tries to fill in the critical gap in our knowledge regarding the dose-response for the effect green exposure on stress reduction.
CHAPTER 3: CONCEPTUAL FRAMEWORK

This chapter explains the theoretical perspective, the conceptual framework, the main research questions along with the hypothesis and assumptions associated with this study.

The main purpose of this study is to understand the relationships between natural environment and stress recovery process within urban park settings. The context of the study is chosen as urban parks in cities offering recreation and green space to residents and visitors of the city.

3.1 The Conceptual Framework:

A review of the exiting environment and behavior research literature (Hartig et al., 1991; Kaplan & Kaplan, 1989; Kaplan, Kaplan, & Ryan, 1998; Ulrich, 1981) indicates that access to and contact with nature (both active and passive) has an influence on the mental health outcomes of people. This influence is rather strong among urban residents (Maas, Verheij, Groenewegen, Sjerp, & Spreeuwenberg, 2006) who are constantly exposed to daily urban stressors and nature has substantial stimulus on the acute stress recovery in urban residents (Hartig et al., 2003). Literature (Maas et al., 2006; Maller, Townsend, Pryor, Brown, & Leger, 2005; Sullivan & Kaplan, 2016) also suggests that parks and urban green environments are complex spaces where there are a variety of features which facilitate human interaction with nature. However, there is lack of
conclusive research findings on specific design elements in parks that have the maximum impact on recovery from stress as discussed in the literature review section.

Throughout the literature review, a number of authors have indicated that the main characteristics of parks can be broken down into five broad categories including landform, water, vegetation, structure and sky (Howard, Thompson, & Waterton, 2013; Schauman, 1979) (See Figure 10). Though all these elements can be ultimately be modified by human action, landform, water, vegetation and structure can be readily controlled by human decisions within urban park settings (Dee, 2005). The importance of green or vegetation has been well established in literature (Groenewegen, van den Berg, de Vries, & Verheij, 2006; San Martin-Feeney, 2014) as the the most important element of any park or landscape. However, there is still a need for a better understanding of how much of vegetation or green exposure creates better health outcomes (Figure 11).
Figure 10: Elements of an Urban Park
Figure 11: Vegetation Types in Urban Parks
The following figure (Figure 12) illustrates the conceptual framework of for this study and its variables.

For the purpose of this study, the focus is on evaluating the density of vegetation associated with the amount of stress reduction among its users. Under the landscape design, vegetation densities are defined as the independent variables. The relationships between physical settings of urban parks and the changes in the stress levels of people are examined through the indicators of vegetation density including:

a) a densely vegetated setting (high density)

b) a moderately vegetated setting with intervening pathways (medium density)
c) a plain field or play field with distant views (low density)

d) a setting with no natural elements (control group)

The level of stress, measured using STAI scores and salivary alpha-amylase and cortisol, is defined as the dependent variable. The age group and the time of day when the samples were collected was controlled for. In addition, gender and race/ethnicity have been defined as the moderating variables for this study. The effect of the stress induction task and the topography or type of place that the participant grew up in may also have a moderating effect on the dependent variables. Though this study uses an Immersive Virtual Environments (IVEs), images of a real park setting were used to create the IVEs. Modified versions of an actual park setting were used for the nature-treatment groups during the recovery period. So familiarity with that specific park may have a mediating effect on the stress outcome.

3.2 Research Questions and Hypothesis

The question no longer is whether people benefit from being in contact with nature and have better health outcomes. So the benefits of urban parks on physical and mental health is not what is being explored. Rather what needs to be investigated is what is it about the nature that lead to the health benefits. Understanding what about nature and how much of it is good is absolutely essential. What remains unknown from the literature are the key physical design attributes of natural environments (urban parks in this study)
that are associated with stress levels of the users. Is the stress recovery directly proportional to the amount of green exposure? Do the two have a linear relationship?

The main research question of this study is:

*What design attributes of urban parks lead to maximum stress reduction among urban residents?*

*What amount of green exposure is most beneficial for acute stress recovery among urban residents?*

This research questions can be answered by evaluating various design elements of urban parks, one at a time. Literature suggests that only five elements are potentially visible in any given landscape (Schauman, 1979), namely water, landform, vegetation, structure and sky. But, vegetation and water have repeatedly been found to have the most restorative impact on humans (Kuo, 2010; Morris, 2003; San Martin-Feeney, 2014; Townsend & Weerasuriya, 2010). The focus of this study is to evaluate the density of vegetation associated with the amount stress reduction among its users. The goal is to describe the shape of the dose-response curve of how exposure to nature impacts stress reduction. This study also seeks to examine whether gender or race lead to any differences in physiological stress responses and stress recovery from nature exposure.

Apart from evaluating the association of the vegetation density with the levels of stress reduction, this study also seeks to examine the role of color, form and texture that may
play a role in stress reduction along with the density or amount of vegetation from the
interview responses.

This study hypothesizes that there will be some amount of change in the stress levels of
people before and after being exposed to a particular park setting, irrespective of which
setting they are exposed to and the amount of stress change will differ for each setting.
The stress levels of the participants are measured at three different stages during the
study.

\[ T1 = \text{Before TSST / Pre-Stressor (for baseline measure)} \]
\[ T2 = \text{After TSST / Post-Stressor / Pre-Treatment (for elevated measure)} \]
\[ T3 = \text{After Nature exposure / Post-Treatment (for declined measure)} \]

Below are the main research questions of the study followed by a null and alternative
hypothesis.

**Research Question 1: Does exposure to nature influence stress?**

**RQ 1A:** Is brief exposure to nature enough to produce a significant calming effect from
a stressful event?

**RQ 1B:** Is there a difference in the stress levels of people recovering from a stressful event
who are exposed to some kind of nature during their recovery period as compared to
those who do not have any nature exposure?
Null Hypothesis 1: There will not be a statistically significant difference in the stress levels of participants who are exposed to nature during their recovery period as compared to those who are not as measured by the salivary alpha-amylase levels.

Alternative Hypothesis 1: There will be a statistically significant difference in the stress levels of participants who are exposed to nature during their recovery period as compared to those who are not as measured by the salivary alpha-amylase levels.

Research Question 2: How much exposure to nature influences stress?

RQ 2A: When recovering from a stressful event, what amount of vegetation density produces maximum calming effect or fosters fastest stress recovery?

RQ 2B: During the recovery period, what is the difference in the stress reduction among participants of different groups when exposed to different densities of vegetation ranging from no vegetation to extremely high density of vegetation?

Null Hypothesis 2:

There will not be a statistically significant difference in the stress levels of participants of different groups, irrespective of the amount of vegetation density they were exposed to as measured by the salivary alpha-amylase levels.

Alternative Hypothesis 2:

There will be some difference in the stress levels of participants within different densities of vegetation groups. One group will have a statistically significant difference in stress
levels as compared to the control or no-vegetation group as measured by the salivary alpha-amylase levels.

Control \((T_3-T_2) \approx\) Low Density \((T_3-T_2) <\) Moderate Density \((T_3-T_2) \approx\) High Density \((T_3-T_2)\)

**Research Question 3: Does more exposure to nature mean lesser stress?**

**RQ3A:** Do higher densities of nature elicit greater stress recovery? Is the relationship linear, or does the effect lessen with greater and greater amounts of vegetation?

**RQ 3B:** For participants who experience nature during the recovery period, is the stress recovery directly proportional to the amount of vegetation density or do any other groups show higher stress reduction?

**Null Hypothesis 3:** The stress recovery will be directly proportional to the amount of vegetation in the different groups, i.e., highest density of vegetation will lead to greatest stress recovery as measured by the salivary alpha-amylase/cortisol levels. The highest vegetation group will have a statistically significant difference in stress recovery as compared to the control or no-vegetation group.

**Alternative Hypothesis 3:** The stress recovery will be not directly proportional to the amount of vegetation in the different groups, i.e., highest density of vegetation will not necessarily lead to greatest stress recovery as measured by the salivary alpha-amylase/cortisol levels. The medium density vegetation group will have a statistically significant difference in stress recovery as compared to the control or no-vegetation group. The
high-density and low-density groups will generate a smaller amount of stress reduction as compared to the medium density group.

\[
\text{Control} \ (T_{3-T2}) \leq \text{Low Density} \ (T_{3-T2}) < \text{Moderate Density} \ (T_{3-T2}) \geq \text{High Density} \ (T_{3-T2})
\]

Hypothetically, the decline in stress level \((T_{3-T2})\) should be the minimum for the control, low for the low vegetation group and higher for the moderate and high vegetation groups.

\[
\text{Control} \ (T_{3-T2}) < \text{Low Density} \ (T_{3-T2}) < \text{Moderate Density} \ (T_{3-T2}) < \text{High Density} \ (T_{3-T2})
\]

However, the hypothesis is that the decline in stress levels in the control group and the low vegetation density group may be similar and the decline in stress levels in the moderate and high density vegetation groups may be approximately same.

\[
\text{Control} \ (T_{3-T2}) \approx \text{Low Density} \ (T_{3-T2}) < \text{Moderate Density} \ (T_{3-T2}) \approx \text{High Density} \ (T_{3-T2})
\]

**Research Question 4: Does race or gender matter in stress recovery?**

**RQ 4A:** Are there any gender differences in the relationship between exposure to different vegetation densities in nature and stress reduction when controlling for age and time?

**RQ 4B:** Are there any racial/ethnicity differences in the relationship between exposure to different vegetation densities in nature and stress reduction when controlling for age and time?
Apart from the main research questions, this study also seeks to tests the efficacy of the different methodologies that have been used in the study including, stress induction through Trier Social Stress Test (TSST), physiological measurements of stress using salivary alpha-amylase and cortisol and the potential for using Immersive Virtual Environments (IVEs) as a surrogate for real natural environments.

**RQ 5:** Can Trier Social Stress Test (TSST) serve as an effective tool for moderate stress induction in laboratory settings in psychobiological and human-behavior studies?

**RQ 6:** Does the stress measurement through self-reports complement the findings from biomarkers of stress measurement including salivary alpha-amylase and cortisol?

**RQ 7:** Can Immersive Virtual Environment (IVE) technology be used to complement more traditional methods to study human preferences, perceptions and behaviors related to built and natural settings?

**RQ 8:** How are the visual design attributes of a park associated with stress recovery among the park users?
CHAPTER 4: RESEARCH METHODOLOGY

This study is situated within the Environment-Behavior and Environmental-Psychology research domains and uses a multi-method approach for investigation. This chapter explains how taking a multi-method approach addresses the research questions and helps understand the amount of green exposure through urban parks in association with stress recovery among its users. This chapter brings together many threads introduced through the varied methods and explicates the rationale for each approach taken in this study as compared to other, more commonly used, research methods in the field of design research. This chapter then elaborates the process of developing the specific research instruments that were used for data collection and how they were implemented.

Figure 13: Research Approach
4.1 Research Design Overview: Multi-Method Strategy

Many researchers combine qualitative and quantitative research methods to develop a mixed-method approach while trying to explore complex phenomena (Leedy & Ormrod, 2010). Mixed-method approach combines the strengths of both qualitative and quantitative research. It can neutralize or constraint the drawbacks of using a single method (Creswell, 2009). In addition, employing a mixed-method approach enables application of sequential explanatory strategy which is characterized by the collection and analysis of quantitative data in the first phase of research followed by collection and analysis of qualitative data in the second phase that builds on the results of the initial quantitative data (Creswell, 2009). This second phase of qualitative data collection helps the researchers interpret the quantitative data and explain the occurrence of any usual or unexpected results in the first phase. Mixed-method approach also enables triangulation of results, where the both qualitative and quantitative data is collected simultaneously, enabling the researchers confirm and cross-validate the results (Creswell, 2009).

Multi-methods allow the researcher to collect robust evidence that deals with complicated questions (Yin, 2009). Studying complex issues, like understanding the influence of nature on mental health of people, virtually requires a multi-method approach, not only for the breadth of coverage, but also to allow for a check on validity of individual methods (Sommer & Sommer, 2002). The merger of quantitative and
qualitative methods extends the internal validity of the findings as it accentuates the strengths and neutralizes the weaknesses of each individual method (Groat & Wang, 2002).

In order to answer the posed research questions for this study, i.e., to evaluate the specific design elements of urban parks in association with maximum stress recovery among the users, both qualitative and quantitative research methods were used. Within the quantitative research domain, quasi-experimental approach was taken to measure the impact of urban green spaces on the stress-levels of people. A survey method was used to gather general demographics, health and park use data from the participants of the quasi-experimental study. However, quantitative data alone cannot explain which design features are most beneficial for stress recovery and why they may have a certain effect on stress levels in people. Thus, in addition to the quantitative methods, this research employed qualitative methods to interpret the results and describe the complex phenomena studied. A descriptive narrative based research method, focusing on systematic enquiry using narrative methods to generate knowledge, was used to collect qualitative data from the focus group (Leedy and Ormrod, 2005).

4.2 Research Design:

In the field of design research, the investigators have a freedom of choice in terms of methods, techniques and procedures that best meet their requirements and purpose
(Creswell, 2009). The researcher not only selects a qualitative, quantitative or mixed methods study to conduct, but also decides on the strategies of inquiry within these three choices.). What investigation strategy a researcher chooses to study a problem with depends on the way the problem is defined, what the researcher wants to examine, the nature of the subject matter being studied, previous knowledge or theories that the study is based on and the type of results desired (Zeisel, 1984).

The primary goal of this research study is to examine what design attributes of urban parks have the biggest impact on stress levels in those who use the parks. However, this is a very broad question and can be answered by evaluating the various design elements of urban parks, one at a time. For this study, the researcher focused on the amount of green exposure (vegetation densities) that causes maximum stress recovery within a short time. The following section describes how some methods are more suited for addressing the research questions and how they were employed.

### 4.2.1 Method 1: Quasi-Experimental Design

In the field of research, an experimental research approach is frequently portrayed as the standard against which all other research strategies should be judged; as the essence of ‘scientific’ research (Groat & Wang, 2002). Experimental research is characterized by: the use of a treatment or independent variable, the measurement of outcome or
dependent variable, a clear unit of assignment (to the treatment), the use of a comparison or control group and focus on causality. Experimental research seeks casual connections between two or more variables. By the manipulation of a variable within a controlled setting, the effect of that variable’s behavior upon other variables is observed and certain conclusions are drawn from these observations. While experimental research is most suited to testing the behavior of inanimate objects, it can also be used in studying behavior in people (Groat & Wang, 2002).

In the field of design research, case study approach is one of the most commonly used methods to study causal relationships between different variables. While a case study can broadly be classified as qualitative approach to inquiry, an experimental approach is used to collect quantitative data (Creswell, 2009). When a researcher wants to develop intensive knowledge about one complex entity, he/she uses a case study approach as it is designed to understand one object as a whole. An experimental design is useful to a researcher when he/ she intends to test the effects of actions by observing differences between a situation in which an action is taken and another in which it is not taken. (Zeisel, 1984).

Experimental design is the most credible device for determination of causality. It seeks to uncover casual connection between variables, and by manipulation of a variable within a controlled setting, the effect of that variable up on other variables is observed
(Groat & Wang, 2002). An experimental design approach is particularly suitable for tracing cause-and-effect relationships (Sommer & Sommer, 1997). An experiment is usually a designed comparison between a sample divided between control observations and some ‘experimental’ observations on sample objects or people. Like correlational research, experimental research concerns relationships between variables. The researchers in an experiment research study the impact of one or more specific, identifiable variables on the phenomenon. These variables that are manipulated or controlled by the researcher, are considered to be treatment, independent variables. The impacts of the treatment are specified by measuring certain outcomes, dependent variables (Groat & Wang, 2002).

While the case studies approach is an in-depth investigation of a single instance, they often have limited generalizability and representativeness because of their narrow focus on few units (Yin, 1989). Experimental research on the other hand, can be replicated. The researcher can lay out a set of clear protocols for the way the experiment has to be conducted and the same method can be used to repeat the process elsewhere to examine if similar results can be achieved (Zeisel, 1984). This makes it possible for the experiment to be conducted in different locations and at different times. The more number of times same results are obtained, the more confident we can be that the theory being tested is valid thus making the results generalizable (Sommer & Sommer, 1997).
The distinction between experimental and quasi-experimental research rests on the manner in which the units of assignment are selected. The comparability of the treatment groups is more precisely established through random assignment which is referred to as a true experiment. ‘Quasi experiments’ are used to approximate the conditions of the true experiment in a setting which does not allow the control and/or manipulation of all relevant variables (Isaac & Michael, 1995). The researcher must clearly understand what compromises exist in the internal and external validity of the design and proceed within these limitations. An ‘experimental design’ would be a statistical comparison, a statistical research methodology, which quantitatively compares the measurements of the experimental group against the control group and reaches a conclusion whether or not the independent variable had a ‘statistically significant impact’ upon the dependent variable (Creswell, 2009).

One of the main reasons for selecting an experimental approach for this study is that it allows for control of variables. However, this study uses a convenient sample (students and employees of North Carolina State University) and the participants are not assigned from the entire population; therefore, it is a quasi-experimental method. The eligible recruited participants get randomly assigned to either one of the three intervention groups or the control group. The repeated-measures within-group and between subject approach can help address the research question of this study. The quasi-experimental
approach also helps control for factors such as age, health conditions, occupancy status, etc. that can affect the stress levels in people.

Though innumerable studies have established the link between exposure to nature and health benefits, few outcome-based studies have been conducted to micro-examine the components of the natural environment that are restorative in character. By the use of a quasi-experimental design, the focus of the study can be narrowed down to examining the relationship between each design element in park setting and the levels of stress reduction. Most visible elements of a park setting or any landscape include vegetation, water, landform, structure and sky. Each of these elements can be tested separately to examine its effect on stress reduction. Further studies can also look at different sub-characteristics of each of these elements (for example, focusing on vegetation, it can be sub-characterized by form, texture, color, density, plantation pattern such as liner or cluster, etc.). Use of a quasi-experimental approach helps lay out a set of protocols for the procedure and the experiment can be repeated innumerable times to study the effect of different independent variables. The cumulative results from all these experiments can indicate which design elements in the parks are most beneficial for acute stress reduction and these findings can then be translated into design recommendations.

This study is interested in looking at the immediate relief effect from daily urban stressors (acute stress) in people, and therefore it needs to eliminate the influence of any ongoing
or long term stressors. Stress induction is a good way of studying the acute stress levels, because then the focus of the study remains only on the acute stress caused by the induction and the influence of the intervention on stress reduction. This is possible only within a controlled laboratory environment using a quasi-experimental approach.

4.2.2 Method 2: Stress Induction using Trier Social Stress Test (TSST)

The Trier Social Stress Test (TSST) was generated in 1993 at the University of Trier, Germany by Kirschbaum et al. (1993). Since then, this procedure has been used as a standardized experimental protocol to reliably induce stress in human research participants in laboratory settings.

This experimental protocol combines procedures that were previously known to induce stress individually but were not reliable by themselves. The combination of these procedures allows for the induction of moderate psychological stress in a laboratory setting. This protocol consists of an anticipation period and a test period in which the participants must deliver a free speech on a given topic and perform mental arithmetic task in front of an audience. This procedure also makes recording of physiological responses to the stressor feasible (Kirschbaum et al., 1993). Kirschbaum et al. (1993) conducted six independent experiments using this combination protocol and found considerable increase in the concentrations of adrenocorticotropin (ACTH), cortisol (serum and saliva), growth hormone (GH) as well as heart rate among other physiological
responses. Cortisol, which is a reliable indicator of stress, reliably increased 2 to 4 folds above the baseline after the TSST stress induction.

While numerous protocols exist for inducing stress response in a laboratory setting, many fail to provide a naturalistic context or to incorporate aspects of social and psychological stress. Meta-analysis of psychological stress protocols confirms that Trier Social Stress Test (TSST) is by far the most consistent and appropriate standardized protocol for studying the stress hormone reactivity (Birkett, 2011). Researchers believe that TSST (psychological stressor) is a reliable method for elevating heart rate, blood pressure and several endocrine stress markers as compared to a saline injection (physical stressor) (Birkett, 2011). They also advocate that TSST also proves to be a useful alternative to physical stressors such as the cold presser test or treadmill walking, and reproduces the more naturalistic psychological stress of performance in the presence of an evaluative audience (Birkett, 2011). Some researchers also claim that gender, genetics and nicotine consumption which can influence stress responsiveness to psychological stress as well as personality traits show no correlation with cortisol responses to TSST simulation, making it a very reliable tool in psycho-biological researches (Kirschbaum et al., 1993).

TSST also can be modified to meet the needs of various research groups as it generally consists of a three step procedure: a waiting period upon arrival, anticipatory speech
preparation followed by speech performance, and verbal response to a challenging arithmetic problem in the presence of a socially evaluative audience. Social evaluation and uncontrollability have been identified as key components of stress induction by the TSST (Kudielka, 2007; Birkett, 2011). In use for over two decades, the goal of TSST has been to systematically induce a stress response in order to measure differences in reactivity, anxiety and activation of the hypothalamic-pituitary-adrenal (HPA) axis and autonomous nervous system (ANS). Researchers usually use self-reported anxiety, physiological measures (e.g. heart rate), and/or neuroendocrine indicators (e.g. the stress hormone cortisol) in response to the TSST as stress indicators. But recently, many investigators have adopted salivary sampling for stress markers such as cortisol and alpha-amylase (a marker of autonomic nervous system activation) as an alternative to blood sampling to reduce the confounding stress of blood-collection techniques (Birkett, 2011).

One of the main advantages of employing the TSST protocol is that the stressor leads to elevated activity of the hypothalamus pituitary adrenal (HPA) axis and the autonomous nervous system (ANS) only during the TSST period. Studies show that stress perception, anxiety and emotional insecurity as well as physiological and endocrine responses to stress are significantly higher during the TSST as compared to post-TSST ratings (Hellhammer & Schubert, 2012). The levels of stress show a natural decline in the post-TSST period, making it a very effective method for inducing acute stress without any
long term effects on health, especially in studies looking at stress-related disorders or developmental variability of the stress response.

4.2.3 Method 3: Salivary Cortisol/Alpha-Amylase Measurement

The fact that the natural environment is a key determinant of health is irrefutable. Evidence now shows positive relationship between exposure to nature and both mental and physical health (Barton & Pretty, 2010). But at present there is insufficient knowledge to translate findings into detailed guidelines for urban planning and design. In particular, little is known about the strength of the relationships between nature and health, possible group differences, and the spatial conditions (size, type, layout of green space) that promote beneficial effects of nearby nature (Van den Berg, Hartig, & Staats, 2007). One of the big reasons for this is the methodological challenges that come with translating this perspective into design recommendations for architects, planners and designers.

Stress is an important determinant of public health that negatively impacts physical and mental health, including cardiovascular, gastroenterological, immunological, neurological, endocrine and mental/ emotional health status (Beil & Hanes, 2013). But the complex psycho-physiological pathways of stress make measurement via one single marker impossible. Studies have confirmed that the causes of a stress response are highly specific, which in turn makes measuring a stress response possible (Hellhammer, Wüst,
& Kudielka, 2009). To this end, psychologists developed several psycho-analytical techniques like life-events checklists, self-reported levels of chronic strain, daily hassles measures, daily diary approaches, biomarkers (e.g. cortisol, heart rate), etc. (Cohen et al., 1995). Comprehensive questionnaires have been developed to assess the psychological factors associated with stress in humans. However, most researchers in the filed of design use self-evaluation techniques to measure stress outcomes of a particular event or setting. In psychology studies, most stress research utilizes a holistic approach of collecting subjective psychological and objective physiological data to assess stress status. Psychological stress is measured via subjective rating scales. Physiological stress is often measured by salivary analysis due to the validity, reliability and ease of collection of salivary data (Beil & Hanes, 2013).

In the human body, stress is an individual adaptive process to external and internal challenges that is regulated on the systemic and cellular level (Selye, 1950; Mason, 1968 as cited in Hellhammer & Schubert, 2012). When a situation is interpreted as being stressful, it triggers a physiological response by the activation of the hypothalamic-pituitary-adrenal (HPA) axis and the autonomous nervous system (ANS) (Gunnar & Quevedo, 2007).

A stressor or a stressful situation creates a biological response in the central nervous system (CNS) and it travels to the two key components of the CNS: the ANS and the HPA.
axis (Gunnar & Quevedo, 2007). These systems congregate at the hypothalamus where a behavioral response within the individual is signaled (Palkovits, 1987). The ANS produces epinephrine and norepinephrine providing adrenaline to focus attention, support vigilance and arousal (Gunnar & Quevedo, 2007), and activate the HPA axis. The HPA axis produces cortisol, a steroid hormone which impacts brain functioning and behavior (Bohus, de Kloet, & Veldhuis, 1982) as well as regulates important bodily functions and expressions such as the immune system (Palacios & Sugawara, 1982) and emotional expression (Oberlander et al., 2008). The end products of HPA activation (cortisol and catecholamine) are easily measurable in blood, urine and saliva. Technically, any of these can be used as biomarkers of stress. However, the unavailability of direct measurement techniques, spinal fluid sampling, individual variability makes testing most of these biomarkers clinically infeasible. Studies in stress measurement employ autonomic measures such as measure of blood pressure, vagal tone, salivary alpha-amylase or salivary cortisol.

Over the past two decades, studies have routinely used salivary cortisol as a biomarker of psychological stress and related mental or physical diseases (Hellhammer et al., 2009). Salivary cortisol is an entrenched non-invasive measurement of activity in the HPA axis, which is directly present in the saliva (Granger et al., 1999). Cortisol levels in individuals vary diurnally with levels highest in the morning and gradually declining throughout the day (Gunnar & Donzella, 2002). Clinically, determination of salivary
cortisol is used in the assessment of HPA disturbances and depressive disorders, but most frequently as a marker for different kinds of stress induced reactions.

Recent advances in immunoassays have identified salivary alpha-amylase as an indicator of norepinephrine levels in humans and have examined the response of salivary enzyme alpha-amylase to psychologically stressful stimuli. Experimental studies suggest that alpha-amylase response to certain types of psychological stress is similar to the cortisol response (Nater et al., 2005; Takai et al., 2004) and also show that the onset of alpha-amylase response to stress is more rapid than cortisol (Takai et al., 2004). Thus salivary alpha-amylase, which also follows a diurnal pattern, is now being considered as a substitute biomarker for SNS (Granger et al., 2006).

These patterns of activity in the HPA axis and the ANS promote homeostasis within the stress response system (McEwen & Seeman, 1999). As the activities in the SNS and HPA axis are dependent on one another, the measurement of both systems provides a more complete understanding of the stress response system (Bauer, Quas, & Boyce, 2002; Granger & Fortunato, 2008).

Given the fact that stress is a physiological response even if the determinants of stress are primarily psychological, using salivary cortisol and salivary alpha-amylase as biomarkers for assessing the interventions in this study gives it a wider acceptance and
scientific relevance. Salivary cortisol and salivary alpha-amylase as biomarkers for stress measurement is much more effective than any of the self-report methods because of the following reasons. First, as a biological measure, salivary cortisol and alpha-amylase do not rely on the interpretation of test questions or subjective perception of emotional state. Second, they are unaffected by acquiescence or fear of retribution, which are common on psychological tests with an institutionalized population. Third, because cortisol is closely associated with physical health and well-being, any environmental feature which affects cortisol might have important implications for the health of adults.

4.2.4 Method 4: Immersive Virtual Reality Environment

Environmental Psychology is the study of the connections between behavior and/or experience and the built and/or natural environment and deals with the interactions between humans and their environments (Kort & Ijsselsteijn, 2003; Bell, Greene, Fisher, & Baum, 2001). Many environmental psychologists believe that since environmental influence on behavior is critical, any research in this discipline should involve naturalistic studies of behavior situated in actual environments, limiting the settings chosen for the study to be outside the laboratory (Bell et al., 2001). However, this is not always feasible for a number of reasons. Not only that the absolute appropriate setting may not always be available, but also the logistics of doing a field study may be too great. The extend of control that the researcher can achieve in this case is also extremely limited (Kort & Ijsselsteijn, 2003).
Most interdisciplinary researchers who study how individual’s behaviors, values, beliefs, attitudes and perceptions are influenced by the built and natural environment have used a variety of methodologies. Participant observations, behavior mapping, surveys, interviews and laboratory experiments are extensively used, with use of static imagery or basic dynamic media (e.g., videos) being the dominant methods of representing built and natural environments. However, the limitations of each of these methodologies to accurately represent and precisely control for environmental stimuli often lead to inconclusive and ambiguous results (Smith, 2015).

To overcome this, many researchers now employ Immersive Virtual Environment (IVE) technology as a complementary methodological tool in their research studies. Simulation of the essential elements of a naturalistic setting in a laboratory increases experiential realism and external validity, while retaining the experimental objectivity (Kort & Ijsselsteijn, 2003; Smith, 2015). Immersive virtual environments can potentially become an extremely vital research tool, even future (virtual) laboratories if people’s behavior and reactions to virtual environments are similar to those in real environments.

A virtual environment is an artificial world, created with computers. Researchers define a virtual environment as ‘synthetic sensory information that leads to perceptions of environments and their contents as if they were not synthetic’ (Blascovich et al., 2002).
Immersive virtual environments (IVE), instead, are ones that ‘surround’ an individual and create the perception they are enclosed within and interacting with environments that provide a continuous stream of stimuli (Smith, 2015). These virtual environments give the observer a sense of ‘being there’ (presence) in the projected environment. All immersive virtual environments are generated through the assimilation of different hardware and software systems. These include a user interface displaying the virtual environment to users (such as head-mounted display and one or more projection displays), a tracking system recording the users’ movements and interaction with the environment (such as cursor keys, joysticks, or head trackers) and a computer that selects appropriate portions of the virtual environment to be displayed within the interface (Kort & Ijsselsteijn, 2003; Smith, 2015). Researches can also include other stimuli such as sounds, scents and even thermal cues to create a more accurate representation of the real environment for the users.

Many researchers have investigated the effectiveness and reliability of immersive virtual environments as compared to real environments and have consistently found IVE to be capable of provoking responses and behavior similar to those portrayed in real environments (Kort & Ijsselsteijn, 2003). While some researchers suggest that an entirely digitalized or computer simulated virtual environment may not generate the same responses as the corresponding real environment (Bishop & Rohrmann, 2003), others vouch for its dependability in replicating results, especially when real environment
images are used to create the immersive virtual environment (Depledge, Stone, & Bird, 2011; Smith, 2015).

Recent advancements in the immersive virtual environment technologies, the flexible and adaptable feature of the virtual environments to suit different kinds of research studies and the declining costs of application have made this method increasingly popular among researchers from various disciplines. IVE technology is rapidly becoming a ubiquitous part of our modern technologically integrated lives. Environmental-psychologists and environment-behavior researchers are now embracing this method to study the human-environment interactions and the reciprocal relationships between the two. Use of virtual environments is now helping researchers improve their understanding of interconnections among the environment, human health, and wellbeing. Researchers are now opting for robust mixed-methods designs using IVE technology along with more traditional laboratory or field-based experiments to examine novel and previously unexplored phenomena (Smith, 2015).

Since IVEs are characterized by virtue of the ability of their designers to be able to vary subtle features of the simulation, a number of recent studies have used this technology to obtain a better understanding of the influence of natural environments in promoting health and well-being (Depledge et al., 2011). Researchers are now exploring the possibilities of employing IVEs not just as a methodology to study different environments’
influences on stress and anxiety (Depledge et al., 2011; Jiang, Chang, & Sullivan, 2014; Lindquist, Lange, & Kang, 2016) but also as a means to provide therapy in treatment of anxiety disorders (Opris et al., 2012) and post-traumatic stress disorders (Botella, Serrano, Baños, & García-Palacios, 2015).

### 4.2.5 Method 5: Structured Interview

Face-to-face interviews provide an excellent way of exploring complex feelings, attitudes and emotionally loaded topics (Sommer & Sommer, 1991). Interviews most often produce more accurate information than any other types of procedures that seem on the surface to be more rigorous and objective. Structured interviews, with questions formulated in advance and asked in a set order, provide consistency in information collected from the respondents (Sommer & Sommer, 1997). Interviews with the participants are essential to understanding behavior in different environments, since each individual experiences and perceives the environment differently. The use of interviews also allows the researcher to explore things cannot be seen or heard in an observation, such as the reasoning behind an action or choice.

Since this study is interested in exploring the role of specific physical design attributes of the urban parks in preference or restoration responses, and their association with recovery from stress, it is absolutely essential to understand the participants’ experience of the virtual park that view during the study.
4.3 Development of Research Instrument:

4.3.1 Image Selection for the Quasi-Experiment:

Selecting the right park setting to be used for the immersive virtual reality environment was a critical step of the process. Figure 14 illustrates the approach taken to select the images for the experimental process.

![Image Selection Process Diagram]

*Figure 14: Image Selection Process*
4.3.1.1 Photographic Survey

First, eight different urban parks were identified across three states, namely North Carolina, South Carolina and Georgia. These parks were picked based on their design features and proximity to urban settings. These parks comprised of varied design complexities and scales, mixed styles, densities of vegetation, diverse forms and types of water features, different kinds of slopes and landform, assorted built and designed elements as well as varied levels of openness and enclosure.

The parks that were selected included: Pullen Park (Raleigh, NC), Marla Dorell Park (Kids Together Playground-Cary, NC), Latta Park (Charlotte, NC), Falls Park (Greenville, SC), Finlay Park (Columbia, SC), Piedmont Park (Atlanta, GA), Morgan Falls Park (Atlanta, GA) and Historic Fourth Ward Park (Atlanta, GA). Following are some of the images taken by the author at different parks.
Figure 15: Examples of Pullen Park Images

Figure 16: Examples of Marla Dorell Park Images

Figure 17: Examples of Latta Park Images
Figure 18: Examples of Falls Park Images

Figure 19: Examples of Finlay Park Images

Figure 20: Examples of Piedmont Park Images
The purpose in this phase was to finalize on one image of a park setting that would be used for the immersive virtual reality environment. The selection of parks was not most relevant as the goal was to evaluate design setting, not the park itself. Over 400 images were taken in all across these eight different parks. All the photographs were taken between 9.30 am – 11.30 am at the same time of the year keeping the sunlight, shadow pattern and foliage consistent. The light conditions were also equalized on each photo.
These images were then filtered down to a collection of 40 photographs that depicted different park elements as well as different densities of vegetation.

A photographic survey (Appendix A) was then distributed to landscape architecture students and experts in the field of landscape design through various means such as LinkedIn, Facebook groups, emails and in person. This survey asked the experts to categorize the images based on density into three groups- high, medium and low density founded on their professional experience and knowledge. The experts were also asked to select the top five favorite park images and rank them according to the likelihood of a person visiting those locations when they were stressed or depressed. There was no time limit for the procedure. The purpose of this phase was to gather the expert opinion on the available park settings and also to come up with the final park setting that would be used for the immersive virtual reality environment in the experimental component.

4.3.1.2 Images for Immersive Virtual Reality Environment

The results of the photographic survey were used to pick the top rated images by the experts. The image that was most frequently picked among the top five images by the experts was qualified as the final setting to be used for the immersive environment, which was at the Falls Park in Greenville, South Carolina.
A GigaPan Epic Pro robot, mounted on a tripod was setup at the selected spot at Falls Park (Figure 23). Using a DSLR camera mounted on the GigaPan robot, 360-degree panorama images were captured. The GigaPan Epic Pro robot was programmed to capture a series of 54 images at the selected location as per the user manual (Appendix B). The 54 image capture cycle was repeated three times at the same location, without moving the tripod from its original location to ensure that all the 54 frames were captured clearly. These images were taken between 10 am – 11am during the month of July to control for the sunlight, shadow pattern and foliage.
(A) **Image Acquisition**
An array of approximately 54 images high-resolution images were captured with a DSLR mounted on a robotic controller GigaPan Epic Pro. Images overlapped by approximately 40%

(B) **Image Stitching**
Image arrays were stitched together based on invariant points shared between the adjacent images. This created one large equirectangular panorama image.

(C) **Image Manipulation**
The equirectangular image was modified as per requirements for the quasi-experiment

*Figure 23: Process for creating Immersive Virtual Environment as per Smith (2015)*
(D) Image Conversion to VE
Original and manipulated equirectangular images were then mapped to six sides of a virtual cube, known as cube-mapping. Each face of the cube was saved as a separate image and read by the dedicated virtual reality software.

(F) Image Projection using Oculus
The Immersive Virtual Environment created was displayed using a head-mounted device, Oculus Rift and participants were allowed to experience this image for 3 minutes.

*Figure 24: Process for creating Immersive Virtual Environment (contd.) as per Smith (2015)*
The 54 images were then stitched together using AutoPano Giga 4.0 software that matched the images in the correct rows and columns creating one seamless equirectangular panorama. Pano2VR software was then used to convert the equirectangular panorama into 6 cube face images that could be used with the Oculus Rift head mounted device to create the immersive virtual reality environment (Smith, 2015). Figure 23 and 24 illustrate the step taken to create the Immersive Virtual Environment.

Using the same method, another set of images of a covered parking deck, with no natural elements, were captured, stitched together and made ready for use with the Oculus Rift. This image was used for the participants in the control group.
Figure 25: Image projected through Oculus Rift head-mounted device
4.3.1.3 Image Modification

As described above, the selected park setting was photographed and a 360-degree panorama was created by stitching the 54 images together. This equirectangular panorama was used to serve as the moderate density vegetation image (Figure 26) for the immersive virtual environment, which comprised of one of the intervention groups.

This image was then digitally modified in two different ways. The amount of vegetation in this image was modified to fit two different scenarios. In the first scenario, the amount of foliage and vegetation was reduced keeping all other elements in the image unscathed. The deduction of vegetation, however, changed the amount of enclosure and openness of the image, while creating pockets of space that were digitally filled up by replication of the already existing features. This image served as the ‘low density
vegetation’ setting (Figure 27). In the second scenario, a number of trees matching the exiting vegetation were added to the image, keeping all other landscape features unaltered. The addition of vegetation, in this case, changed the amount of enclosure/openness and visibility of other park features like the pathways, the seating area and the distant views. This image served the ‘high density vegetation’ setting (Figure 28). The image of the parking deck (Figure 29) was used for the control group.
4.3.2 Quasi-Experiment Setup:

4.3.2.1 Sample Size and Effect Size

Multiple a priori power analyses were conducted to investigate the requirements for analyzing the data in different ways. Each analysis yielded a different sample size
requirement. The data analysis that was used for the current study is elaborated below.

G*Power (Version 3.1.9.2) computer software package (Faul, Erdfelder, Lang, & Buchner, 2009) was used to conduct an a priori power analysis for a two-way between-factors ANOVA. The number of groups was set to 4 (corresponding to the four recovery conditions), and the number of measurements were set to 3 (corresponding to the three time points at which the saliva samples would be collected). The overall effect size was set to $F = 0.25$ (corresponding to a medium effect size according to published standards; Cohen, 1992), and the alpha level was set to 0.05. The analysis revealed that an overall sample size of 100 participants would yield a power of 0.80 at the 0.05 significance level using the aforementioned estimated parameters.

Table 1: Sample Size Determination

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4.3.2.2 Participants

A call for participation in the study was promoted through direct advertising to the students of North Carolina State University. The advertisement was distributed through email-lists (Appendix C1) received from various departments and also in the form of posters (Appendix C2) placed in different departments. The study was also advertised on social media including Facebook (as Wolfpack Students, NCSU OIS, NC State, etc.) (Appendix C3) that helped to reach out to a larger group of students. Verbal announcements were also made in some classes by the principal investigator or the lecturers.

Interested participants were asked to contact the principal investigator to determine whether or not they meet the eligibility criteria and to schedule a date and time for the study participation. If individual met the inclusion/exclusion criteria he/she was asked to be present at a specific location at a particular time.

The eligibility requirements for the study were as follows:

- Age: between 18- 35 years
- No history of cardiovascular diseases, depression, or post-traumatic stress disorder.
The study did not restrict participation of vulnerable populations including pregnant women and persons with physical disabilities. Though these vulnerable populations would not have been specifically included or excluded from the study as long as they were a part of the general student population at North Carolina State University. There were no subjects that fell in these categories. Each participant had a chance to win one of the five $25 gift cards for NC State Bookstore that were given out as prizes. Winners were selected through a drawing at the end of the study.

A total of 105 participants between the age of 18-35 years were recruited for the study. The age gap is kept low to minimize the variation in alpha-amylase and cortisol levels due to age.

4.3.2.3 Trier Social Stress Test (TSST) Panel

A group of current graduate (PhD) students along with a post-doc researcher from the College of Design served as the panel for the TSST task. They were recruited upon agreement with the faculty advisor. The participation of this panel was completely voluntary and there was no conflict of interest. Once the research panel was selected, they met with the researcher for training before the actual lab experiment began. They were provided with the background information about the study and were also given the required readings to have a holistic understanding of the study in order to gain clarity on the roles they were supposed to play.
On the onset of the study, this team continued to meet weekly with the researcher to monitor the progress of the study and to discuss any issues faced during the study or any other related concerns. The researcher was also present for every session of the TSST and played the role of one of the panelist during that procedure.

4.3.2.4 Treatment and Control Group Images for IVE

Following the methods described above, three images of urban parks for the treatment group and one image for the control group were created and used with the Oculus Rift head-mounted gear.

4.4 Data Collection / Quasi-Experimental Procedure:

The eligible participants were asked to refrain from alcohol consumption 24 hours prior to the participation as well as abstain from use of tobacco, caffeine, exercise and medication 2 hours before their scheduled time of the experiment. All procedures were performed between 11am-2pm in order to control for diurnal variations of cortisol and alpha-amylase secretion (Pruessner et al., 1997). These sessions were all conducted from mid-January to mid-March 2016.
4.4.1 Step 1- TSST Setup

a) Two rooms (Figure 31) were made available to conduct the Trier Social Stress Test (TSST). A comfortable waiting area was available to participants prior to beginning the TSST and during recovery periods. A separate interview room was used during the speech preparation, speech performance and math portions of the TSST to introduce novelty and uncontrollability.
b) One researcher (R1) and one confederate (C1) were present for every experiment. The confederates were from a group of graduate students selected through the process described above and only one of them attended at one time depending on their availability. The confederates had no contact with the participant prior to the TSST.

- Researcher (R1) was responsible for greeting the participant, giving him/her a description of the procedure, guiding him/her from one room to another and debriefing the participant.
- Confederate 1 (C1) was the only person to speak to participant during the TSST.

c) The interview room was arranged so that the participant was facing the confederate and researcher while seated. The video recording equipment was positioned in the visual field of the participant. Both the researcher and the confederate were dressed formally during the TSST to increase stress during the TSST.

d) The confederate was instructed to maintain eye contact with participants and refrain from making emotional facial expressions during the TSST.

All equipment needed to record physiological, psychological or endocrine responses to the TSST was set up and kept ready. This included collection materials for the saliva samples and an iPad that was used to collect responses to the post-TSST and post-intervention questionnaire digitally.
4.4.2 Step 2- Introduction and Basal Measures:

a) On the day of the experiment, when the participant arrived on location, he/she was greeted and asked to sit quietly in the waiting room for a minute. The participant was then given a brief introduction of the experiment that he/she would be a part of.

b) The participant was then asked to digitally sign the consent form (Appendix E) once he/she agreed to participate in the following procedures of the study. A printed copy of the signed consent form was given to the participant for his/her record. The participant was assigned a unique identification number that was the only link between the participants’ names and other data collected from them.

c) The participant was then asked to fill out a short demographic and health background questionnaire (Appendix F) and other information about food or beverage (other than water) consumption in the past hour was collected. Responses to 10-item Perceived Stress Scale (PSS) (Appendix G) were also collected at this time.

d) The participant was asked to wait comfortably in the waiting room for 15 minutes. The waiting room was equipped with reading material such as magazines containing emotionally-neutral content in case the participant would like to read while waiting. He/she was asked to refrain from using his/her cell phone or other electronic devices during this time.

e) A ‘pre-stress’ saliva sample (T1) was collected from the participant. He/she was instructed to rinse their mouth with water. The participant was given a clean oral swab (Figure 32) and a clean, disposable 2.0 ml polypropylene vial. He/she was
instructed to chew on the oral swab for a minute without biting on it and then asked to place the swab into the vial. A timer was set for 60 seconds to allow the participant to produce enough saliva. The participant was left alone in the room during this time to provide privacy. The collected sample was labeled and stored at -20° C immediately.

The participants had the right to stop the procedure at any time if he/she was not comfortable with the experiment and could withdraw from being a part of the study at any time.

Figure 32: SalivaBio Oral Swabs from Salimetrics

4.4.3 Step 3- Stress Induction through The Trier Social Stress Test (TSST):

a) After the 15-minute wait time and the basal measures, the participant was brought from the waiting room to the interview room.
b) Researcher (R1) read a pre-prepared script (Appendix H) to the participant to begin the speech preparation period, while pointing towards the confederate (C1). The participant was given a hypothetical situation where he/she was being interviewed for his/her ‘ideal job’ that paid a very high salary. The participant was given 5 minutes to prepare a 5-minute speech explaining why he/she would be the best candidate for the position. The participant was informed that the confederate was a public speaking expert and would rate the participant’s speech for its believability and convincingness. The participant was also informed that his/her speech was going to be recorded so that it can be evaluated later for content and non-verbal behavior.

c) A digital timer was set for 5 minutes and the participant was allowed to prepare in solitude. The participant was also allowed to take notes during this preparation period.

d) After 5 minutes, the researcher (R1) turned on the video camera to increase evaluative/ performance stress and confederate (C1) asked the participant to begin speaking and continue speaking for the entire 5 minutes by reading a pre-prepared script (Appendix H). A digital timer was set for 5 minutes for the speech task.

e) The researcher and the confederate maintained direct eye contact with the participant throughout and refrained from making any emotional facial expression during the TSST procedure. Both behaved in a reserved manner and provided no verbal or facial feedback during the participant’s performance.
f) If the participant stopped talking during the speech, he/she was allowed to remain silent for 20 seconds and was then prompted to resume speaking after informing him/her that there was more time remaining.

![Figure 33: Panel of Interviewers for TSST](image)

At the end of 5-minute speech, the participant was asked to stop speaking and was asked to perform an arithmetic task as per the script (Appendix H). In this task, the participant had to sequentially subtract an odd two-digit number from an even four-digit number.
h) The participant was asked to verbally report his/her answers and was also informed that he/she would have to start from the beginning in case a mistake was made. A digital timer was set for 3 minutes for the math task.

i) The researcher and the confederate took notes throughout the participant’s performance.

j) After the end of the math performance portion of the TSST, the researcher brought the participant back out into the waiting area. The participant was then asked to fill out a 20-item post-TSST questionnaire (Appendix I) that was based on State-Trait Anxiety Inventory-S (STAI-S) scale to access the intensity of the participant’s current feelings or state.

k) After 15 minutes, a ‘post-stress’ (T2) saliva sample was collected, labeled and stored as described earlier.

l) If at any time the participant appeared to be having an adverse reaction, i.e. began to cry or seemed overly agitated or blanked-out, the researcher asked the participant if he/she was okay and wanted to continue.

m) The researcher was prepared to stop the experiment at any time that any participant was not comfortable enough to continue. The procedure would have been stopped immediately and the researcher would have debriefed the participant about the purpose of the study and the tasks he/she was asked to perform. Information about the necessary resources for counseling and stress management at NC State University’s Health Center were kept handy in case any participant was
overwhelmed and had to seek advice. Fortunately, there were no such instances during the experimental procedures.

4.4.4 Step 4- Nature Treatment (NT):

a) After the TSST and the 15-minute wait period, the participant was randomly assigned to one of the study groups (Appendix D). The study had 4 groups, namely one control group and three intervention groups.

b) The participant was asked to wear a head mounted device, Oculus Rift DK1, that projected an immersive virtual reality image of a setting (Figure 28). The intervention groups saw an urban park, a nature setting with different densities of vegetation while the control group saw an image of an enclosed parking deck, a setting with no natural elements. The participants spent 5 minutes experiencing this immersive environment and responding to it.

c) The participant and the confederate interviewers who administered the TSST did not know which setting the participant will get to watch.

d) After the 5 minute of immersive environment exposure, the participant was asked to wait comfortably for 15 minutes in the waiting room. He/she was asked to refrain from use of cell phone or any electronic device during this time. The participants were asked to fill out a 20-item post-treatment questionnaire (Appendix J) that was based on State-Trait Anxiety Inventory-S (STAI-S) scale to access the intensity of the participant’s current/present feelings or state.
e) After 15 minutes, a ‘post-treatment saliva sample (T3) was collected, labeled and stored as described earlier.

This was followed by a brief questionnaire (Appendix K, Appendix L) that investigated the participant’s park use in general, his/her familiarity with the park image that he/she experienced and his/her perception of the setting.

4.4.5 Step 5- Semi-Structured Interview:

a) The survey questions were followed by a brief semi-structured interview (Appendix M) with the participant. These interviews were recorded after gaining consent from the participants and were later transcribed for further investigation.
b) The semi-structured interview asked the participant to describe the urban park setting that he/she experienced through the immersive environment, gathered information about certain design features that he/she liked or disliked, discussed about addition or elimination of design features that would make the urban park more attractive and restorative according to the participant.

c) The interview also discussed about participant’s choice of healing places and activities he/she prefers when a mood-lift is needed.

The main purpose of the semi-structured interviews was to help provide an in-depth understanding of how the specific park setting or features influenced the participant's experience of space. It may help determine which other features of the park setting apart from the vegetation contributed to the changes in mood, experience and behavior of the respondents. Semi-structured interviews would help understand the users' feeling, perceptions and attitudes towards the park settings.

### 4.4.6 Step 6- Debriefing:

a) After the semi-structured interview, the participants were debriefed about the true nature of the experiment giving them a clear idea of the purpose of the study.

b) The participants were informed that their performance in the tasks was not being evaluated or scored in any way and that their speech was also not being recorded. It was also make clear to them that the study intends to use naturally occurring stress
hormone in the body called cortisol and how it responds to stressful situations as well as to nature; which is why it was necessary to induce stress in the participants using a standard stress induction method (Appendix N).

The researcher apologized to the participants for not revealing the true nature of the study at the beginning, answered the questions raised the participants had and made sure they were feeling okay to leave.

4.5 Stress Measures:

4.5.1 Perceived Stress Scale (PSS) Score:

The Perceived Stress Scale (PSS) is one of the most commonly used psychological instrument to measure an individual’s perception of stress (Cohen & Williamson, 1988). This scale includes a number of queries about an individual’s current levels of experienced stress and situations that an individual appraises as stressful, unpredictable and uncontrollable. Researchers have found correlations between the Perceived Stress Scale scores and stress measures, self-reported health, health behavior measures and help seeking behavior (Cohen et al., 1988). The 10-item PSS was used in the current study that asked questions about the participants’ feelings and thoughts during the last four weeks and the responses were recorded on a five-point Likert Scale. The PSS scores were obtained by reversing the responses (e.g., 1 = 5, 2 = 4, 3 = 3, 4 = 2 & 5 = 1) to the four positively stated items (items 4, 5, 7, & 8) and then summing across all scale items.
4.5.2 Saliva Samples collection and handling:

Measurement of salivary alpha-amylase and cortisol is a non-invasive technique to measure the body’s stress response that have been employed by researchers for several years. Both alpha-amylase and cortisol levels vary naturally in the body when exposed to stressful and calming situations and therefore, multiple collection process throughout the study have been used to accurately measure the change in stress levels. For this study, saliva samples were collected at three different time points.

First sample was collected 15 minutes after the participant had arrived and rested in the waiting area (Sample at T1). This was also just before the onset of the Trier Social Stress Test (TSST). The second sample was collected 15 minutes after the stressor (Sample at T2) and the third sample was collected at 15 minutes after the treatment using Oculus (Sample at T3). All samples were collected using Salimetrics Oral Swabs (SOS) that were previously bought from Salimetrics LLC. located at State College, Pennsylvania. These oral swabs come individually wrapped to minimize the possibility of environmental contaminants with usage instructions printed on the back of the package. The participants were asked to place the swab under the tongue (according to instructions from Salimetrics- Appendix O) and allow it to soak in the saliva for one minute. A timer for 60 seconds was set for this time. After the one-minute time period, the SOS was immediately inserted into tube insert (basket) of the swab storage tube. These swab storage tubes were bar-coded to match the participant’s unique identification number as
well as the stage at which the sample was collected. Immediately after collection, the storage tubes were placed in a 4” tube storage box and frozen at -20° Celsius (temperature of a regular household freezer). After the sample collection from all participants during the day, the samples were transported on ice to a -80° C freezer for storage until assayed.

Figure 35: Workspace in Salimetrics Center for Excellence Laboratory, UNC
Once all the samples were collected from all the participants, they were taken to the Bio-Behavioral Lab at the School of Nursing, University of North Carolina in Chapel Hill which is the Center of Excellence for Salimetrics. The samples were transported on dry-ice in a thermosafe insulated bio-shipper box.

4.5.3 Testing for Saliva Alpha Amylase Assay:

Salivary alpha-amylase assay kits, available through Salimetrics LLC. (State College, PN) were purchased. The kits (Figure 36) consisted of alpha-amylase substrate solution, alpha-amylase controls (high and low), alpha-amylase diluent, as well as a 96-well microtiter plate to run the reactions. The high control was a vial containing 100 uL of a high level of salivary alpha-amylase (273.77 U/mL ± 68.44 U/mL) and the low control was a vial containing 100 uL of a low level of salivary alpha-amylase (22.55 U/mL ± 9.02 U/mL). These high and low controls were used as standards during the assay procedure and gave a general idea of what the high and low levels of salivary alpha-amylase would look like.
Saliva samples were first removed from the -80°C freezer, thawed and spun at 3000 rpm in a centrifuge machine for 15 minutes. The centrifuge pulled the saliva out of the oral swab into the bottom of the Salivette tube. This provided a clear, fluid sample that was free of cellular debris and mucus prior to the assay procedure. Collecting a ‘clean’ sample was important as any foreign substance suspended in the sample can potentially influence the reading obtained from the sample. This is why using an oral swab proves
to be a better collection method as compared to passive droll as it reduces the amount of mucus and other substances such as food particles in the sample.

The samples were then serially diluted to a 1:200 dilutions before the assay was performed. This was done by first pipetting 10uL of saliva into 90uL of alpha-amylase diluent. This solution was vortexed and then further diluted by pipetting 10uL of the 1:10 dilutions onto 190uL alpha-amylase diluent (1:20). The final dilution was 1:200. The alpha-amylase substrate solution was simultaneously incubated to 37°C in a trough using the ‘jitterbug’ (Figure 37). The 96-well plastic microtiter plate included in the kit was perforated so that only one strip (8 wells) can be processed during one assay run. The assay strips were also heated to the same temperature.

Precision pipettes and disposable micro-tips were used to pipette 8uL of the controls (pre-diluted) and the diluted saliva/samples to the individual wells. Then, 320uL of preheated (37°C) alpha-amylase substrate solution was added simultaneously to each well using an electronic multi-channel pipette to reduce temperature variance. Reverse pipetting techniques were used in order to avoid introducing bubbles into the wells as this can result in inaccurate measurements by the Microplate reader.

The plate was immediately placed in BioTeK PowerWave XS2 Microplate Reader (Figure 37) and the ‘BBL-SAA.prt’ program was started. This program mixed the microplate for
one minute (500-600 rpm) at 37°C, measured the light absorption (optical density) of each well at 405 nm at exactly one minute, then returned to mixing at 37°C and measured the light absorption of each well at 405 nm at exactly three minutes. Optical densities were recorded and displayed using the Gen5 Microplate reader software that calculated the final alpha-amylase concentrations (in U/mL) and generated a Microsoft Excel spreadsheet as the output.

4.5.4 Testing for Saliva Cortisol Assay:

ELISA-based salivary cortisol assay kits (Figure 38), available through Salimetrics LLC. (State College, PN) were purchased to assess the cortisol levels of the participants. The kits consisted of cortisol enzyme conjugate, cortisol controls (high and low), cortisol
standards (six concentrations), wash buffer concentrate, cortisol assay diluent, TMB substrate solution, stop solution and a 96-well microtiter plate with wells coated with monoclonal antibodies. The high control was a vial containing 50 µL of a high level of salivary cortisol (1.011 µg/dL ± 0.253 µg/dL) and the low control was a vial containing 50 µL of a low level of salivary cortisol (0.104 µg/dL ± 0.026 µg/dL). These high and low controls were used as standards during the assay procedure and gave a general idea of what the high and low levels of salivary cortisol would look like.

This assay also required additional materials not included in the kit. These were precision pipettes and disposable micro-tips for the pipettes. Deionized water was also required for the preparation of the wash buffer solution. BioTeK PowerWave XS2 Microplate Reader was used to measure the optical density of the wells and samples at 405 nm. The data collected by the plate reader was recorded using the Gen5 Microplate Reader Software.

Saliva samples were first removed from the -80°C freezer, thawed and spun at 3000 rpm in a centrifuge machine for 15 minutes. All reagents were brought to room temperature. 100 mL of the 10x wash buffer was added to 900 mL of Millipore water and used as the plate wash buffer. The cortisol samples were pre-made at the following concentrations: 3.0 µg/dL, 1.0 µg/dL, 0.333 µg/dL, 0.111 µg/dL, 0.037 µg/dL and 0.012 µg/dL. These standards were arranged in the correct descending order from left to right, high to low.
12 mL of assay diluent was measured and set aside in a capped polypropylene tube.

Figure 38: Salivary Cortisol Enzyme Immunoassay Kit

Samples, standards, and controls were all organized into an assay layout sheet prior to running the assay reactions. This helped determine which wells received samples or standards, as well as how many wells were required for the run. Micropipettes were then used to load the wells of the microtiter plate. All the samples, standards and controls
were run in duplicates to assure accurate readings. The standards and controls (high and low) were vortexed and 25 mL of each was pipetted into the appropriate wells. 25 mL of the samples (not vortexed) was also pipetted into the assay plate. Once all the samples had been added to the plate, 8 uL of the enzyme conjugate was added to 12 mL of the assay diluent that was set aside earlier. This was then vortexed, added to a single channel reservoir and 200 uL of this mixture was added to each well using a multi-channel pipette. The filled plate was then rotated on the plate rotator for 5 minutes and incubated at room temperature for 55 minutes, covered with a lid to protect from light and dust.

After 55 minutes, the plate was washed 4 times with 300 uL/ well of wash buffer and blotted on a stack of blot paper. 200 uL of TMB solution was then added to each well using a multichannel pipette and kept protected from light. The plate was mixed for 5 minutes in the dark (covered with a lid) and then incubated in the dark at room temperature for 25 minutes. The wells turned blue during this time, the darker blues indicating higher concentrations of cortisol and lighter indicating lower levels.

After 25 minutes, 50 mL of the stop solution was added to each well using the multichannel pipette, turning the wells yellow. The plate was rotated for 3 minutes and then read at 450 nm using the BioTeK PowerWave XS2 Microplate Reader.
Figure 39: Additional Images from Salimetrics COE Laboratory
CHAPTER 5: DATA ANALYSIS

The main questions addressed in this chapter include:

1) Did the stress induction using Trier Social Stress Test method generate significant amount of stress in the participants with a brief amount of time?

2) Does exposure to or contact with nature through urban parks have more positive effects on people’s recovery from stress after a stressful event as compared to exposure to an urban environment?

3) Is there an association between the amount of green or vegetation densities and the amount of stress recovery after a stressful event? Is the stress recovery directly proportional to the amount of green exposure? Do the two have a linear relationship?

4) What amount of green or vegetation brings about the maximum recovery from stress given the same amount of time of nature exposure? Does adding more and more trees to an urban park yield faster recovery and more positive experience of the park? Or is there a point at which, in terms of stress recovery, additional vegetation will have a minimal effect, no effect, or even a negative effect?

5) What other features of the urban park in addition to vegetation densities help people recover from stress after a stressful event?

To answer these questions a survey embedded quasi-experimental study was conducted (N = 103) followed by structured interviews and both quantitative and qualitative data
was collected. Quantitative data contributed to the interpretation of which urban park settings lead to the greatest and fastest recovery from acute stress while the qualitative data provide rich information about the design of urban parks.

This chapter begins with the descriptive analysis of the sample’s feature, followed with the detailed analysis of the changes of participants’ salivary alpha-amylase and salivary cortisol levels. Then, it describes the analysis of participants’ mood changes based on self reports from STAI scale scores. Finally, it analyses and explores the interview data to examines the design characteristics of the most beneficial park setting.

SPSS 23.0 was used for all statistical analyses and various statistics methods were used to answer the posed research questions. First descriptive statistics and frequency analysis were performed using the information gathered from the demographic questionnaire. After completing the descriptive analysis, a correlation analysis was conducted on the STAI scores, salivary alpha-amylase and salivary cortisol levels to examine the
relationship between physical and psychological outcome measures related to stress and anxiety. This methodology was designed to assess changes in hormone levels related to stress as well as psychological changes related to anxiety following the nature treatment, and to check the validity of the measurements. After the reliability analysis, variance of analysis between the pre and post treatment scores for self-reported state anxiety scores (STAI Scale) was conducted. A two-way repeated measures analysis of variance (ANOVA) was conducted to examine the mean variance from pre to post-treatment for both salivary alpha-amylase and salivary cortisol. Post-hoc analysis was conducted to explore the mean differences in the STAI scores and salivary alpha-amylase levels to test the differences between each of the experimental groups.

5.1 Descriptive Analysis of the Participant Sample

After the study was advertised, a total of 137 individuals showed interest in the study and contacted the author for participation. The study had established an inclusion criterion for including only those who fall within the age group of 18 to 35 years with no history of cardio-vascular diseases, depression, or post-traumatic stress disorder. Of the 137, 7 individuals did not meet the inclusion criteria. Of the remaining who were eligible, 23 individuals could not make it at the scheduled time for the study due to various reasons. One individual who was eligible and came in for the study refused to participate after reading the consent form. Thus, a total of 106 individuals participated in the study (male= 63 and females= 43). Saliva samples were collected from all 106
participants at three time points during the study and analyzed for salivary alpha amylase and salivary cortisol levels. During the saliva assay testing, it was noted that 2 participants did not produce enough volume of saliva to run the saliva assay tests in duplicates and so their data was eliminated from the analysis. One participant’s saliva sample had very high readings of alpha-amylase and cortisol levels and his/her information was also eliminated from the analysis.

Figure 41: Sample Size
Thus, in the end, data from 103 participants, including 62 males and 41 females, was analyzed and used for this study. The total number of individuals who participated and whose data was analyzed can be seen in Figure 41.

Table 2 provides a description of the sample. There were 26 participants (male =18, female =8) assigned to Treatment Group-1 (i.e., low vegetation density), 26 participants (male =12, female =14) assigned to Treatment Group-2 (i.e., medium vegetation density), 26 participants (male =12, female =14) assigned to Treatment Group-3 (i.e., high vegetation density), and the Control Group had 25 number of participants (male =20, female =5). For the age variable, 58 participants were 18-23 years old, 40 were 24-30 years old, and 5 participants were aged between 31-35 years. Among all participants in the sample, 42 were White, 10 in Treatment Group 1, 11 in Treatment Group 2, 12 in Treatment Group 3 and 9 in the Control Group. There were 15 African American/ Black in total, with 3 in Treatment Group 1, 5 in Treatment Group 2, 3 in Treatment Group 3 and 4 in the Control Group. Among the total 33 Asians, 9 were in Treatment Group 1, 6 were in Treatment Group 2, 9 were in Treatment Group 3 and 9 were in the Control Group. As for the Hispanic and Latino participants, there were a total of 13 participants, with 4 in Treatment Group 1, 4 in Treatment Group 2, 2 in Treatment Group 3 and 3 in the Control Group (see Table 2).
Table 2: Participant Sample Description

<table>
<thead>
<tr>
<th>Experimental Group/Category</th>
<th>Low Density</th>
<th>Medium Density</th>
<th>High Density</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>18</td>
<td>12</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>Participant's Gender</td>
<td>MALE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>18</td>
<td>12</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>Female</td>
<td>8</td>
<td>14</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>Participant's Age</td>
<td>18-23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-23</td>
<td>14</td>
<td>17</td>
<td>16</td>
<td>11</td>
</tr>
<tr>
<td>24-30</td>
<td>11</td>
<td>6</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>31-35</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Relationship Status</td>
<td>Single</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>23</td>
<td>21</td>
<td>25</td>
<td>19</td>
</tr>
<tr>
<td>Married</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Current Status at NCSU</td>
<td>Full Time Student</td>
<td>25</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Part Time Student</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td>White/ Non-Hispanic</td>
<td>10</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>African American/ Black</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Asian</td>
<td>9</td>
<td>6</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>25</td>
</tr>
</tbody>
</table>

The frequency analysis of participants’ educational levels is shown in Table 5. In the present study, there were 51 undergraduate students, 41 master-level graduate students, and 11 doctoral student participants. Of the total number of participants, 93 were enrolled full-time while 10 were enrolled part-time at NC State University (see Table 6). In addition, the participants had diversified major background, including Engineering, Design, Humanities and Social Sciences, Education, Management, Agriculture and Life Sciences, textiles and Natural Resources. A detailed descriptive analysis of participants’ majors or department affiliations is shown in Table 3.
Table 3: Descriptive Analysis of Participant's Major/Department

<table>
<thead>
<tr>
<th>Department Affiliation</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>College of Engineering</td>
<td>35</td>
<td>34.0</td>
</tr>
<tr>
<td>College of Design</td>
<td>15</td>
<td>14.6</td>
</tr>
<tr>
<td>College of Humanities and Social Sciences</td>
<td>14</td>
<td>13.6</td>
</tr>
<tr>
<td>College of Sciences</td>
<td>13</td>
<td>12.6</td>
</tr>
<tr>
<td>College of Education</td>
<td>11</td>
<td>10.7</td>
</tr>
<tr>
<td>College of Textiles</td>
<td>5</td>
<td>4.9</td>
</tr>
<tr>
<td>Poole College of Management</td>
<td>5</td>
<td>4.9</td>
</tr>
<tr>
<td>College of Agriculture and Life Sciences</td>
<td>3</td>
<td>2.9</td>
</tr>
<tr>
<td>College of Natural Resources</td>
<td>2</td>
<td>1.9</td>
</tr>
<tr>
<td>Total</td>
<td>103</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Figure 42: Distribution of Participant's Major/Department
As seen from Perceived Stress Scale scores the Table 4, it can be said that in the current study sample, males (M=11.94) have higher perceived stress scores as compared to females (M=11.07). Similarly, participants aged between 31-35 years have higher perceived stress (M=13.20) as compared to other ages groups of 18-23 years (M=11.67) and 24-30 years (M=11.27). Undergraduate (M=11.73) and graduate students (M=11.73) have higher perceived stress as compared to doctoral students (M=10.45). Race or ethnicity also seems to effect the perceived stress with African American/ Black participants (M=12.33) and Hispanic/ Latino participants (M= 12.08) having higher perceived stress as compared to Asians (M=11.79) and White Americans/ Non-Hispanic participants (M=11.02).

Table 4: Participants' Perceived Stress Scale Scoring

<table>
<thead>
<tr>
<th>Category</th>
<th>N</th>
<th>Mean</th>
<th>Median</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant's Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MALE</td>
<td>62</td>
<td>11.94</td>
<td>10.50</td>
<td>4.515</td>
</tr>
<tr>
<td>FEMALE</td>
<td>41</td>
<td>11.07</td>
<td>10.00</td>
<td>3.764</td>
</tr>
<tr>
<td>Participant's Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-23</td>
<td>58</td>
<td>11.67</td>
<td>10.00</td>
<td>4.383</td>
</tr>
<tr>
<td>24-30</td>
<td>40</td>
<td>11.27</td>
<td>10.50</td>
<td>3.889</td>
</tr>
<tr>
<td>31-35</td>
<td>5</td>
<td>13.20</td>
<td>14.00</td>
<td>5.630</td>
</tr>
<tr>
<td>Degree level</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undergraduate</td>
<td>51</td>
<td>11.73</td>
<td>10.00</td>
<td>4.313</td>
</tr>
<tr>
<td>Graduate</td>
<td>41</td>
<td>11.73</td>
<td>11.00</td>
<td>4.025</td>
</tr>
<tr>
<td>Doctorate</td>
<td>11</td>
<td>10.45</td>
<td>9.00</td>
<td>4.845</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White/ Non-Hispanic</td>
<td>42</td>
<td>11.02</td>
<td>10.00</td>
<td>4.087</td>
</tr>
<tr>
<td>African American/ Black</td>
<td>15</td>
<td>12.33</td>
<td>12.00</td>
<td>5.394</td>
</tr>
<tr>
<td>Asian</td>
<td>33</td>
<td>11.79</td>
<td>10.00</td>
<td>3.967</td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>13</td>
<td>12.08</td>
<td>13.00</td>
<td>4.153</td>
</tr>
<tr>
<td>Total</td>
<td>103</td>
<td>11.59</td>
<td>10.00</td>
<td>4.234</td>
</tr>
</tbody>
</table>
5.2 Stress-Inducing Effect of Trier Social Stress Test

To test the stress-reducing effects of different images of the urban park, an essential part of the study was that the participants' stress levels were elevated before viewing the different treatment and control group images. As described as a part of the methodology, Trier Social Stress Test (TSST) was used to induce stress in the participants within the laboratory setting. The levels of stress were recorded using self-reported STAI-S scale measures as well as physiological measures including salivary alpha-amylase and salivary cortisol levels. To determine whether or not the TSST produced a stress response in the participants, paired t-test was conducted on the salivary alpha-amylase and salivary cortisol levels sampled before and after the TSST.

In order to reduce the bias from individual differences (e.g., some participants’ salivary cortisol and alpha-amylase levels were inherently higher than the others), the readings are transformed into percentages. The value of salivary alpha-amylase and salivary cortisol that was measured 15 minutes after the stressor (post-stressor value) was used as the representative of the stressful states of the participants.

A paired-sample t-test was conducted to evaluate whether a statistically significant difference existed between the mean salivary alpha-amylase levels sampled before (and after the stress induction task. Assumption testing indicated no gross violation of assumptions. Participants on an average had significantly higher salivary alpha-amylase
levels post-stressor (N=103, M=34.83, SD=14.64) as compared to pre-stressor (N=103, M=272.54, SD= 98.22). The results of the paired-sample t-test, as seen in Table 9, were significant, t (102)= 27.47, df=102, p<0.001. The mean increase was 237.72 with 95% confidence interval for the difference between the means of 220.55 to 254.88. The observed power was 0.88 indicating a very large effect based on Cohen’s conventions (1988).

Table 5: Increase in Salivary Alpha-Amylase Post-Stressor

<table>
<thead>
<tr>
<th>Paired Samples Statistics</th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salivary AA- Pre Stressor</td>
<td>34.8256</td>
<td>103</td>
<td>14.639549</td>
<td>1.442478</td>
</tr>
<tr>
<td>Salivary AA- Post Stressor</td>
<td>272.54277</td>
<td>103</td>
<td>98.222809</td>
<td>9.678181</td>
</tr>
</tbody>
</table>

Paired Samples Test

<table>
<thead>
<tr>
<th>Paired Differences</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sal_AA Pre-Stressor</td>
<td>-</td>
<td>87.828303</td>
<td>8.653980</td>
<td>-254.882332 - -</td>
<td>-</td>
</tr>
</tbody>
</table>
| Sal_AA Post Stressor| 237.717204 | - | 8.653980 | - | 220.552076 - 27.469 | 102 .000

An independent t-test was conducted to determine if a difference existed in the post-stressor increase in salivary alpha-amylase levels between the male and female participants. The results of the Levene’s Test, F=101, p=0.8, indicate that the variance of the two populations are assumed to be approximately equal and thus the standard t-test results were used. There was no statistically significant difference in the increase in
salivary alpha-amylase levels of males (n=62, M=240.12, SD=84.61) and females (n=41, M=234.09, SD=93.43), t (101)= 0.34, p>0.05. The effect size was very small (less than 0.001). The 95% confidence interval was -29.19 to 41.26 (See Table 6).

Table 6: Gender Differences in Increase in Salivary Alpha-Amylase Post-Stressor

<table>
<thead>
<tr>
<th>Participant's Gender</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in Salivary</td>
<td>MALE</td>
<td>62</td>
<td>240.11905</td>
<td>10.746107</td>
</tr>
<tr>
<td>Alpha-Amylase Post</td>
<td>FEMALE</td>
<td>41</td>
<td>234.08515</td>
<td>14.591372</td>
</tr>
<tr>
<td>Stressor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Independent Samples Test

<table>
<thead>
<tr>
<th>F</th>
<th>Sig.</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
<th>Mean Difference</th>
<th>Std. Error Difference</th>
<th>95% Confidence Interval of the Difference Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>.055</td>
<td>.815</td>
<td>.340</td>
<td>101</td>
<td>.735</td>
<td>6.033902</td>
<td>17.756469</td>
<td>-29.190156</td>
<td>41.257960</td>
</tr>
</tbody>
</table>

The same procedures were conducted to evaluate whether a statistically significant difference existed between the mean salivary cortisol levels sampled before and after the stress induction task. Assumption testing indicated no gross violation of assumptions. The results of the paired-sample t-test, as seen in Table 7, were significant, t (102) = 17.09, df=102, p < 0.001. Participants on an average had significantly higher salivary cortisol levels post-stressor (N=103, M=0.64, SD=0.35) as compared to pre-stressor...
The mean increase was 0.50 with 95% confidence interval for the difference between the means of 0.44 to 0.56. The observed power was 1.35 indicating a very large effect based on Cohen’s conventions (1988).

Table 7: Increase in Salivary Cortisol Post-Stressor

<table>
<thead>
<tr>
<th>Paired Samples Statistics</th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sal-Cortisol Pre-Stressor</td>
<td>.13363</td>
<td>103</td>
<td>.066823</td>
<td>.006584</td>
</tr>
<tr>
<td>Sal-Cortisol Post-Stressor</td>
<td>.63504</td>
<td>103</td>
<td>.354361</td>
<td>.034916</td>
</tr>
</tbody>
</table>

Paired Samples Test

<table>
<thead>
<tr>
<th>Paired Differences</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Mean</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sal-Cortisol Pre-Stressor – Sal-Cortisol Post-Stressor</td>
<td>-.501408</td>
<td>.297847</td>
<td>.029348</td>
<td>-.559619</td>
<td>-.443197</td>
<td>-17.085</td>
<td>102</td>
<td>.000</td>
</tr>
</tbody>
</table>

An independent t-test was conducted to determine if a difference existed in the post-stressor increase in salivary cortisol levels between the male and female participants (Table 8). The results of the Levene’s Test, F=101, p=0.08, indicate that the variance of the two populations are assumed to be approximately equal and thus the standard t-test results were used. There was no statistically significant difference in the increase in salivary alpha-amylase levels of males (n=62, M=0.58, SD=0.34) and females (n=41,
M=0.38, SD=0.17), t (101)= 3.45, p > 0.05 The effect size was very small (less than 0.001). The 95% confidence interval was -0.08 to 0.31.

**Table 8: Gender Differences in Increase in Salivary Cortisol Post-Stressor**

<table>
<thead>
<tr>
<th>Participant's Gender</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in Sal-Cortisol Post-Stressor</td>
<td>MALE</td>
<td>62</td>
<td>.57977</td>
<td>.33634</td>
</tr>
<tr>
<td></td>
<td>FEMALE</td>
<td>41</td>
<td>.38290</td>
<td>.171718</td>
</tr>
</tbody>
</table>

**Independent Samples Test**

<table>
<thead>
<tr>
<th></th>
<th>Levene's Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
<th>95% Confidence Interval of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>Sig.</td>
<td>t</td>
</tr>
<tr>
<td>Increase in Sal-</td>
<td>Equal variances assumed</td>
<td>2.965</td>
<td>.088</td>
</tr>
<tr>
<td>Cortisol Post-Stressor</td>
<td>Equal variances not assumed</td>
<td>3.901</td>
<td>95.824</td>
</tr>
</tbody>
</table>

The stress-inducing effect (by percentage) of the stressor Trier Social Stress Test (TSST) was calculated for salivary alpha-amylase and salivary cortisol levels as:

\[
\text{Stress-Inducing Effect (d)} = \frac{(M_{\text{post-stressor}} - M_{\text{pre-stressor}})}{SD_{\text{pre-stressor}}} \times 100\%
\]

The mean salivary alpha-amylase levels increased more than 300% (Cohen’s \(d = 3.19\)) and salivary cortisol levels increased more than 55% (Cohen’s \(d = 0.56\)) from the baseline to immediately after the stress-inducing TSST procedure.
Clearly, all analyses mentioned in this section suggest that the Trier Social Stress Test produced a stressful experience for the average participant. The TSST’s effect was also examined by gender and ethnicity. The effect sizes for salivary alpha amylase and salivary cortisol level remain significant. These results demonstrate that TSST is an effective stressor for both genders as well as for all ethnic/racial groups.

5.3 Interrelation among the three measures of Stress Responses

As a part of this study, self-reported measures of stress from STAI-S scores as well as physiological measures of stress from salivary alpha-amylase and cortisol were recorded. All three measures of stress served as the dependent variables for indicators of stress levels in this study. To eliminate repetition of data analysis, Pearson correlation analysis was conducted on the three measures of decrease in stress levels after the treatment, namely decrease in STAI scores, decrease in salivary alpha-amylase and decrease in salivary cortisol levels.

Pearson correlation analysis was conducted to test the null hypothesis that there is no correlation between the decrease in stress levels as measured from salivary alpha-amylase level, salivary cortisol level and self-reported STAI scores (N=103). Preliminary analysis showed that there were no violations in the assumptions of normality, linearity or homoscedasticity. Results indicated that there is significant evidence to reject the null hypothesis and conclude that there is a strong positive association between the decrease
in salivary alpha-amylase levels ($M=96.36, SD=44.41$), decrease in salivary cortisol levels ($M=0.12, SD=0.11$) and decrease in STAI scores ($M=25.45, SD=12.91$), $r(102)=0.37, p<0.01$. Decrease in salivary alpha-amylase levels and salivary cortisol levels were highly correlated with decrease in STAI scores as seen in Table 9 and Figure 44.

**Table 9: Correlation Analysis between decrease in Salivary Alpha-Amylase levels, Salivary Cortisol levels and STAI Scores**

<table>
<thead>
<tr>
<th>Descriptive Statistics</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decrease in Salivary-AA Post-Treatment</td>
<td>96.36012</td>
<td>44.410968</td>
<td>103</td>
</tr>
<tr>
<td>Decrease in Salivary Cortisol Post-Treatment</td>
<td>.12058</td>
<td>.118199</td>
<td>103</td>
</tr>
<tr>
<td>Decrease in STAI Score Post-Treatment</td>
<td>25.45</td>
<td>12.918</td>
<td>103</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Correlations</th>
<th>Decrease in Salivary-AA Post-Treatment</th>
<th>Decrease in Salivary Cortisol Post-Treatment</th>
<th>Decrease in STAI Scores Post-Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decrease in Salivary-AA Post-Treatment Pearson Correlation</td>
<td>1</td>
<td>.372</td>
<td>.664</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>Sum of Squares and Cross-products</td>
<td>201178.073</td>
<td>199.068</td>
<td>38831.546</td>
</tr>
<tr>
<td>Covariance</td>
<td>1972.334</td>
<td>1.952</td>
<td>380.701</td>
</tr>
<tr>
<td>N</td>
<td>103</td>
<td>103</td>
<td>103</td>
</tr>
<tr>
<td>Decrease in Salivary Cortisol Post-Treatment Pearson Correlation</td>
<td>.372</td>
<td>1</td>
<td>.290</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td></td>
<td>.003</td>
</tr>
<tr>
<td>Sum of Squares and Cross-products</td>
<td>199.068</td>
<td>1.425</td>
<td>45.155</td>
</tr>
<tr>
<td>Covariance</td>
<td>1.952</td>
<td>.014</td>
<td>.443</td>
</tr>
<tr>
<td>N</td>
<td>103</td>
<td>103</td>
<td>103</td>
</tr>
<tr>
<td>Decrease in STAI Scores Post-Treatment Pearson Correlation</td>
<td>.664</td>
<td>.290</td>
<td>1</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td></td>
<td>.003</td>
</tr>
<tr>
<td>Sum of Squares and Cross-products</td>
<td>38831.546</td>
<td>45.155</td>
<td>17021.456</td>
</tr>
<tr>
<td>Covariance</td>
<td>380.701</td>
<td>.443</td>
<td>166.877</td>
</tr>
<tr>
<td>N</td>
<td>103</td>
<td>103</td>
<td>103</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed).**
Based on this analysis, it is clear that the three measurements of stress used in this study are significantly correlated. Results indicate that the correlation between salivary alpha-amylase levels and self-reported measure of stress ($r= 0.66, p< 0.01$) is twice as strong as compared to correlation between salivary cortisol levels and self-reported measure of stress ($r= 0.29, p< 0.01$), suggesting that salivary alpha-amylase is a strong indicator of stress (Table 9).

Previous studies have used salivary cortisol as an indicator for stress and cortisol levels in the body peak after 30-45 minutes after the stressor or treatment (Jones & Bright, 2001). However, alpha-amylase in the body peaks after 10-20 minutes after the stressful event or treatment. In the current study, saliva samples were collected 15 minutes after the Trier Social Stress Test Task and 15 minutes after the participants were exposed to nature via immersive virtual reality environments. Considering the lag in peak time between salivary alpha-amylase and salivary cortisol, only salivary alpha-amylase readings were used for further analysis as reported below. The same analysis was also conducted using the salivary cortisol levels but has been excluded from the main results. The results from the saliva cortisol levels analysis can be found in Appendix R.
Figure 43: Correlation between STAI Scores, Salivary Alpha-Amylase and Salivary Cortisol Post-Stressor

Figure 44: Correlation between STAI Scores, Alpha-Amylase and Salivary Cortisol Post-Treatment
5.4 Stress Recovery in Control Group versus Treatment Group

One of the main assumptions of this research study is that nature has restorative properties and that brief exposure to nature can create a positive experience and help with acute stress recovery. One hypothesis of the current study is that the participants in the treatment group, irrespective of the type of nature exposure, will show greater recovery from stress as compared to the control group participants that had no exposure to nature. To test this hypothesis, the data from the participants in the treatment group was compared to the data from the participants in control group.

5.4.1 Analysis of STAI scores:

A univariate analysis of variance was conducted to test the post-stressor and post-treatment difference on the self-reported levels of stress between the control group and the treatment and groups. Descriptive statistics of this analysis (Table 10) shows a difference in the mean values of the scores between the control group (M= 65.76, SD= 2.90) and the treatment group (M= 45.58, SD= 9.41) indicating that there was a drop in the self-reported stress levels of the participants in these two categories.

<table>
<thead>
<tr>
<th>Experimental Category</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>45.58</td>
<td>9.413</td>
<td>78</td>
</tr>
<tr>
<td>Control</td>
<td>65.76</td>
<td>2.905</td>
<td>25</td>
</tr>
<tr>
<td>Total</td>
<td>50.48</td>
<td>12.020</td>
<td>103</td>
</tr>
</tbody>
</table>
Table 11: Analysis of STAI Scores Post-Treatment: Control versus Nature-Treatment Groups

Tests of Between-Subjects Effects
Dependent Variable: Post Nature Treatment Scoring

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
<th>Noncent. Parameter</th>
<th>Observed Power^b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>7751.942^a</td>
<td>2</td>
<td>3875.971</td>
<td>55.484</td>
<td>.000</td>
<td>.526</td>
<td>110.968</td>
<td>1.000</td>
</tr>
<tr>
<td>Intercept</td>
<td>1644.972</td>
<td>1</td>
<td>1644.972</td>
<td>23.548</td>
<td>.000</td>
<td>.191</td>
<td>23.548</td>
<td>.998</td>
</tr>
<tr>
<td>Post-Stressor</td>
<td>39.851</td>
<td>1</td>
<td>39.851</td>
<td>.570</td>
<td>.452</td>
<td>.006</td>
<td>.570</td>
<td>.116</td>
</tr>
<tr>
<td>GROUP</td>
<td>7751.382</td>
<td>1</td>
<td>7751.382</td>
<td>110.960</td>
<td>.000</td>
<td>.526</td>
<td>110.960</td>
<td>1.000</td>
</tr>
<tr>
<td>Error</td>
<td>6985.748</td>
<td>100</td>
<td>69.857</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>277161.000</td>
<td>103</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>14737.689</td>
<td>102</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. R Squared = .526 (Adjusted R Squared = .517)
b. Computed using alpha =

Figure 45: Stress Reduction using STAI Scores: Control versus Nature-Treatment Groups
The results of this analysis also show that there is a significant difference in the self-reported STAI scores between the two groups (p> 0.05) with about 53% reduction in self-reported stress levels among participants in the treatment group (Table 11). An effect size of 0.25 or 25% is considered as a large effect (Tabachnick & Fidell, 2001) and hence it is evident here that the nature-exposure treatment did create a significantly large effect on the level of stress measured through self-reports.

5.4.2 Analysis of Salivary Alpha-Amylase Levels

Analysis of variance (ANOVA) is a method for comparing mean values for several groups to address the association between a quantitative response variable and categorical explanatory variable (Agresti & Finlay, 2009). Two-way repeated measures ANOVA was conducted at the salivary alpha-amylase level at three different time points: baseline/pre-stressor, post-stressor and post-treatment. The sample population was divided into two groups based on the images that the participants were exposed to, namely, control group and treatment group. This analysis was conducted to identify the differences in the stress recovery between the different treatment groups and the control group.

All participants who experienced the low, medium and high density of vegetation images were included in the treatment group (N= 78) and participants who experienced the parking deck image consisted of the control group (N= 25) (See Table 12).
Table 12: Distribution of participants in the Control and Nature Groups

<table>
<thead>
<tr>
<th>Between-Subjects Factors</th>
<th>Value Label</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>0</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>25</td>
</tr>
</tbody>
</table>

As illustrated in Table 13, there is a difference in the mean values of the salivary alpha-amyrase levels of the participants before the stressor, immediately after the stressor and immediately after the treatment. The pre-stressor mean values are approximately similar for both treatment group (M= 34.52, SD= 14.99) and the control group (M= 35.77, SD= 13.72), indicating that the participants in both groups started at similar baseline stress level. The post-stressor mean values are also similar for the treatment group (M= 272.27, SD= 104.11) and the control group (M= 273.39, SD= 78.89), suggesting an increase in stress levels for participants in both groups. This shows that the Trier Social Stress Test used as the stress-induction method generated uniform stress among all participants irrespective of the group they were assigned to. The post-treatment mean values largely vary between the treatment group (M= 166.88, SD= 90.97) and the control group (M= 213.93, SD= 76.91). This confirms that there is a difference in the stress levels between the participants of the treatment group and the control group. The participants in the treatment group also show lower post-treatment stress values as compared to post-stressor stress values indicating that nature-exposure treatment did aid recovery from stress.
Table 13: Participant’s Salivary Alpha-Amylase Levels Pre-Stressor, Post-Stressor and Post-Treatment

<table>
<thead>
<tr>
<th></th>
<th>Group</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salivary Alpha-Amylase</td>
<td>Treatment</td>
<td>34.52274</td>
<td>14.994931</td>
<td>78</td>
</tr>
<tr>
<td>T1 Pre-Stressor</td>
<td>Control</td>
<td>35.77036</td>
<td>13.719679</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>34.82556</td>
<td>14.639549</td>
<td>103</td>
</tr>
<tr>
<td>Salivary Alpha-Amylase</td>
<td>Treatment</td>
<td>272.27058</td>
<td>104.114304</td>
<td>78</td>
</tr>
<tr>
<td>T2 Post-Stressor</td>
<td>Control</td>
<td>273.39200</td>
<td>78.893380</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>272.54277</td>
<td>98.222809</td>
<td>103</td>
</tr>
<tr>
<td>Salivary Alpha-Amylase</td>
<td>Treatment</td>
<td>166.87801</td>
<td>90.971559</td>
<td>78</td>
</tr>
<tr>
<td>T3 Post-Treatment</td>
<td>Control</td>
<td>213.93312</td>
<td>76.914997</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>178.29916</td>
<td>89.723950</td>
<td>103</td>
</tr>
</tbody>
</table>

Figure 46: Stress Reduction using Salivary Alpha-Amylase Levels:

Control versus Nature-Treatment Groups
The Wilk’s Lambda values suggest there is a significant difference ($p<0.05$) in the salivary alpha-amylase levels of the participants across the three time points when the sample was collected, for both the control and treatment group. The results show 86.3% change in salivary alpha-amylase levels of the participants over time and 33.5% change across time and group combined (Table 14).

### Table 14: Analysis of Salivary Alpha-Amylase Levels: Control versus Nature-Treatment Groups

<table>
<thead>
<tr>
<th>Effect</th>
<th>Pillai's Trace</th>
<th>Wilks' Lambda</th>
<th>Hotelling's Trace</th>
<th>Roy's Largest Root</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>.863</td>
<td>.137</td>
<td>6.325</td>
<td>6.325</td>
</tr>
<tr>
<td></td>
<td>316.271$^b$</td>
<td>316.271$^b$</td>
<td>316.271$^b$</td>
<td>316.271$^b$</td>
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<td></td>
<td>2.000</td>
<td>2.000</td>
<td>2.000</td>
<td>2.000</td>
</tr>
<tr>
<td></td>
<td>100.000</td>
<td>100.000</td>
<td>100.000</td>
<td>100.000</td>
</tr>
<tr>
<td></td>
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<td>.000</td>
</tr>
<tr>
<td></td>
<td>.863</td>
<td>.863</td>
<td>.863</td>
<td>.863</td>
</tr>
<tr>
<td></td>
<td>632.541</td>
<td>632.541</td>
<td>632.541</td>
<td>632.541</td>
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<td></td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Time * GROUP</td>
<td>.335</td>
<td>.665</td>
<td>.503</td>
<td>.503</td>
</tr>
<tr>
<td></td>
<td>25.166$^b$</td>
<td>25.166$^b$</td>
<td>25.166$^b$</td>
<td>25.166$^b$</td>
</tr>
<tr>
<td></td>
<td>2.000</td>
<td>2.000</td>
<td>2.000</td>
<td>2.000</td>
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<td>.335</td>
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</tr>
<tr>
<td></td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
</tbody>
</table>

a. Design: Intercept + GROUP
b. Exact statistic
c. Computed using alpha =

The Mauchly’s Test of Sphericity is significant ($p<0.05$) indicating that there are significant differences between the variance of differences and the condition for sphericity has not been met (Table 15).
Table 15: Mauchly’s Test of Sphericity

Mauchly's Test of Sphericity\(^a\)

<table>
<thead>
<tr>
<th>Within Subjects Effect</th>
<th>Mauchly's W</th>
<th>Approx. Chi-Square</th>
<th>df</th>
<th>Sig.</th>
<th>Epsilon(^a)</th>
<th>Greenhouse-Geisser</th>
<th>Huynh-Feldt</th>
<th>Lower-bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>.445</td>
<td>80.952</td>
<td>2</td>
<td>.000</td>
<td>.643</td>
<td>.654</td>
<td>.500</td>
<td></td>
</tr>
</tbody>
</table>

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

\(^a\) Design: Intercept + GROUP
Within Subjects Design: Time
\(^b\) May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Because the assumption of sphericity was violated, Greenhouse-Geisser values are used to calculate the effect size. Results show that there is a significant difference (\(p<0.05\)) in the salivary alpha-amylase levels of the participants across the three time points when the sample was collected, for both the control and treatment group. The results also indicate a significant difference in the salivary alpha-amylase levels of the participants in the two groups (\(p<0.05\)) with an effect size of 0.82 or 82% change across time and a 5% change across time and group (Table 16).
Table 16: Analysis of Salivary Alpha-Amylase Levels: Control versus Nature-Treatment Groups

<table>
<thead>
<tr>
<th>Source</th>
<th>Sphericity Assumed</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td></td>
<td>2206046.872</td>
<td>2</td>
<td>1103023.436</td>
<td>440.54</td>
<td>.000</td>
<td>.813</td>
</tr>
<tr>
<td></td>
<td>Greenhouse-Geisser</td>
<td>2206046.872</td>
<td>1.215</td>
<td>1815858.830</td>
<td>440.539</td>
<td>.000</td>
<td>.813</td>
</tr>
<tr>
<td></td>
<td>Huynh-Feldt</td>
<td>2206046.872</td>
<td>1.234</td>
<td>1787755.317</td>
<td>440.539</td>
<td>.000</td>
<td>.813</td>
</tr>
<tr>
<td></td>
<td>Lower-bound</td>
<td>2206046.872</td>
<td>1.000</td>
<td>2206046.872</td>
<td>440.539</td>
<td>.000</td>
<td>.813</td>
</tr>
<tr>
<td>Time * GROUP</td>
<td></td>
<td>26556.889</td>
<td>2</td>
<td>13278.444</td>
<td>5.303</td>
<td>.006</td>
<td>.050</td>
</tr>
<tr>
<td></td>
<td>Greenhouse-Geisser</td>
<td>26556.889</td>
<td>1.215</td>
<td>21859.717</td>
<td>5.303</td>
<td>.017</td>
<td>.050</td>
</tr>
<tr>
<td></td>
<td>Huynh-Feldt</td>
<td>26556.889</td>
<td>1.234</td>
<td>21521.401</td>
<td>5.303</td>
<td>.017</td>
<td>.050</td>
</tr>
<tr>
<td></td>
<td>Lower-bound</td>
<td>26556.889</td>
<td>1.000</td>
<td>26556.889</td>
<td>5.303</td>
<td>.023</td>
<td>.050</td>
</tr>
<tr>
<td>Error(Time)</td>
<td>Sphericity Assumed</td>
<td>505768.697</td>
<td>202</td>
<td>2503.805</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Greenhouse-Geisser</td>
<td>505768.697</td>
<td>122.703</td>
<td>4121.904</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Huynh-Feldt</td>
<td>505768.697</td>
<td>124.632</td>
<td>4058.111</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lower-bound</td>
<td>505768.697</td>
<td>101.000</td>
<td>5007.611</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A one-way within-subjects ANOVA was conducted on the salivary alpha-amylase levels. Results show a significant effect of time, accounting for a large portion of variance: $F(2, 202) = 440.54$, $p<0.05$ and partial $\eta^2 = 0.82$ (Table 16). There is a significant quadratic trend, $F(1,101) = 635.38$, $p<0.05$ across time, indicating an initial rise and then a drop in the salivary alpha-amylase levels across time. And a significant quadratic trend, $F(1,101) = 9667.354$, $p<0.05$ across time and group combined, indicating an initial rise and then a drop in the salivary alpha-amylase levels across time and group. The effect size of the quadratic trend is small, 0.045.
Table 17: Analysis of Salivary Alpha-Amylase Levels: Control versus Nature-Treatment Groups

<table>
<thead>
<tr>
<th>Source</th>
<th>Time</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Linear</td>
<td>915952.885</td>
<td>1</td>
<td>915952.885</td>
<td>294.120</td>
<td>.000</td>
<td>.744</td>
</tr>
<tr>
<td></td>
<td>Quadratic</td>
<td>1291105.661</td>
<td>1</td>
<td>1291105.661</td>
<td>635.372</td>
<td>.000</td>
<td>.863</td>
</tr>
<tr>
<td>Time * GROUP</td>
<td>Linear</td>
<td>28738.184</td>
<td>1</td>
<td>28738.184</td>
<td>9.228</td>
<td>.003</td>
<td>.084</td>
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<tr>
<td></td>
<td>Quadratic</td>
<td>9667.354</td>
<td>1</td>
<td>9667.354</td>
<td>4.757</td>
<td>.031</td>
<td>.045</td>
</tr>
<tr>
<td>Error(Time)</td>
<td>Linear</td>
<td>314536.160</td>
<td>101</td>
<td>3114.219</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quadratic</td>
<td>205236.792</td>
<td>101</td>
<td>2032.047</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 47: Salivary Alpha-Amylase Responses to Stressor and Treatment: Control versus Nature-Treatment Groups
5.5 Stress Recovery in Control and the three Treatment Groups

The other main assumption of this research study is that when recovering from a stressful event, different amounts of vegetation densities can produce different levels of calming effects. The current study hypothesizes that recovery from stress is not directly proportional to the amount of vegetation in the different groups, i.e., highest density of vegetation will not necessarily lead to greatest stress recovery. It also hypothesizes that the moderate density vegetation group will generate fastest recovery from stress and will have a statistically significant difference in stress recovery as compared to the control or no-vegetation group.

Two-way repeated measures ANOVA was conducted at the salivary alpha-amylase level at three different time points to identify the differences in the stress recovery between the different treatment groups and the control group. Distribution of the participants in the three treatment groups and the control group can be found in Table 18. Data from a total of 103 participants was analyzed for this study. Treatment Group-1 (i.e., low vegetation density), Treatment Group-2 (i.e., medium vegetation density) and Treatment Group-3 (i.e., high vegetation density) had 26 participants each. The Control Group had 25 participants.
Table 18: Distribution of Participants in 4 Treatment Groups

<table>
<thead>
<tr>
<th>Experimental Group/Category</th>
<th>Value Label</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Low Density</td>
<td>26</td>
</tr>
<tr>
<td>2</td>
<td>Medium Density</td>
<td>26</td>
</tr>
<tr>
<td>3</td>
<td>High Density</td>
<td>26</td>
</tr>
<tr>
<td>4</td>
<td>Control</td>
<td>25</td>
</tr>
</tbody>
</table>

5.5.1 Analysis of STAI Scores:

One-way analysis of variance is used to measure the experimental group differences on the self-reported STAI scores. Table 19 shows the planned contrasts between the four groups and reveals that there is a statistically significant difference between the STAI scores collected post-treatment and not between the scores measured after the stressor.

Table 19: Analysis of STAI Scores between 4 Treatment Groups

<table>
<thead>
<tr>
<th>ANOVA</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post Trier-Social-Stress-Test Scoring</td>
<td>Between Groups</td>
<td>19.642</td>
<td>3</td>
<td>6.547</td>
<td>.295</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>2193.737</td>
<td>99</td>
<td>22.159</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>2213.379</td>
<td>102</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post Nature Treatment Scoring</td>
<td>Between Groups</td>
<td>12586.937</td>
<td>3</td>
<td>4195.646</td>
<td>193.127</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>2150.752</td>
<td>99</td>
<td>21.725</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>14737.689</td>
<td>102</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Contrast Tests

<table>
<thead>
<tr>
<th></th>
<th>Assume equal variances</th>
<th>Does not assume equal variances</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Contrast</td>
<td>Value of Contrast</td>
<td>Std. Error</td>
<td>t</td>
<td>df</td>
<td>Sig. (2-tailed)</td>
<td>Contrast</td>
<td>Value of Contrast</td>
</tr>
<tr>
<td>Post Trier-Social-Stress-Test Scoring</td>
<td>1</td>
<td>-2.05</td>
<td>3.246</td>
<td>-.632</td>
<td>99</td>
<td>.529</td>
<td>1</td>
<td>-2.05</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-1.21</td>
<td>1.319</td>
<td>-.917</td>
<td>99</td>
<td>.361</td>
<td>2</td>
<td>-1.21</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>-.44</td>
<td>1.319</td>
<td>-.334</td>
<td>99</td>
<td>.739</td>
<td>3</td>
<td>-.44</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>-.40</td>
<td>1.319</td>
<td>-.305</td>
<td>99</td>
<td>.761</td>
<td>4</td>
<td>-.40</td>
</tr>
<tr>
<td>Post Nature Treatment Scoring</td>
<td>Assume equal variances</td>
<td>1</td>
<td>-60.55</td>
<td>3.214</td>
<td>-18.841</td>
<td>99</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>-22.45</td>
<td>1.303</td>
<td>-17.236</td>
<td>99</td>
<td>.000</td>
<td>4</td>
<td>-22.45</td>
</tr>
</tbody>
</table>

Turkey HSD Post Hoc analysis of the STAI scores measured post-nature-treatment also shows a statistically significant difference in the score between the experimental groups (Table 20). There was no significant difference between STAI scores of males and females and the scores were consistent across all race and ethnicity groups.
Table 20: Post-Hoc Analysis of STAI Scores within 4 Treatment Groups

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Experimental Group/ Category</th>
<th>(I) Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post Nature</td>
<td>Low Density</td>
<td>18.962</td>
<td>1.293</td>
<td>.000</td>
<td>15.58 - 22.34</td>
</tr>
<tr>
<td></td>
<td>Medium Density</td>
<td>-18.962</td>
<td>1.293</td>
<td>.000</td>
<td>-22.34 - -15.58</td>
</tr>
<tr>
<td></td>
<td>High Density</td>
<td>12.885</td>
<td>1.293</td>
<td>.000</td>
<td>9.51 - 16.26</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>-9.568</td>
<td>1.306</td>
<td>.000</td>
<td>-12.98 - -6.16</td>
</tr>
<tr>
<td>Treatment Scoring</td>
<td>Low Density</td>
<td>12.885</td>
<td>1.293</td>
<td>.000</td>
<td>9.51 - 16.26</td>
</tr>
<tr>
<td></td>
<td>Medium Density</td>
<td>-6.077</td>
<td>1.293</td>
<td>.000</td>
<td>-9.46 - -2.70</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>-12.885</td>
<td>1.293</td>
<td>.000</td>
<td>-16.26 - -9.51</td>
</tr>
<tr>
<td></td>
<td>Low Density</td>
<td>6.077</td>
<td>1.293</td>
<td>.000</td>
<td>2.70 - 9.46</td>
</tr>
<tr>
<td></td>
<td>Medium Density</td>
<td>-22.452</td>
<td>1.306</td>
<td>.000</td>
<td>-25.86 - -19.04</td>
</tr>
<tr>
<td></td>
<td>High Density</td>
<td>9.568</td>
<td>1.306</td>
<td>.000</td>
<td>6.16 - 12.98</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>28.529</td>
<td>1.306</td>
<td>.000</td>
<td>25.12 - 31.94</td>
</tr>
<tr>
<td></td>
<td>Low Density</td>
<td>22.452</td>
<td>1.306</td>
<td>.000</td>
<td>19.04 - 25.86</td>
</tr>
<tr>
<td></td>
<td>Medium Density</td>
<td>28.529</td>
<td>1.306</td>
<td>.000</td>
<td>25.12 - 31.94</td>
</tr>
<tr>
<td></td>
<td>High Density</td>
<td>22.452</td>
<td>1.306</td>
<td>.000</td>
<td>19.04 - 25.86</td>
</tr>
</tbody>
</table>

* The mean difference is significant at the 0.05 level.

Figure 48: Stress Reduction using STAI Scores: 4 Treatment Groups
5.5.2 Analysis of Salivary Alpha-Amylase Levels

Descriptive statistics of this analysis (Table 21) shows a difference in the mean values of post-treatment salivary alpha-amylase levels between the control group and the three treatment groups. For Treatment Group 1 (low vegetation density), the salivary alpha-amylase levels increased from pre-stressor (M= 32.94, SD= 13.95) to post-stressor (M= 264.13, SD= 113.64) and then reduced after the treatment (M= 193.23, SD= 97.74). For Treatment Group 2 (medium vegetation density), the salivary alpha-amylase levels increased from pre-stressor (M= 36.35, SD= 18.78) to post-stressor (M= 264.31, SD= 94.83) and then lowered after the treatment (M= 119.29, SD= 69.13). Similarly, for Treatment Group 3 (high vegetation density) the salivary alpha-amylase levels increased
from pre-stressor (M= 34.28, SD= 11.79) to post-stressor (M=288.37, SD= 105.22) and then reduced post-treatment (M=175.00, SD= 90.81). And finally for the Control Group (no nature) the salivary alpha-amylase levels increased from pre-stressor (M=35.77, SD=13.72) to post-stressor (M=273.39, SD=78.89) and then reduced slightly after the treatment (M=218.85, SD=76.66).

Table 21: Descriptive Statistics of Salivary Alpha-Amylase levels: 4 Treatment Groups

<table>
<thead>
<tr>
<th>Descriptive Statistics</th>
<th>Experimental Group/Category</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salivary Alpha-Amylase</td>
<td>Low Density</td>
<td>32.93715</td>
<td>13.947594</td>
<td>26</td>
</tr>
<tr>
<td>Pre-Stressor</td>
<td>Medium Density</td>
<td>36.35423</td>
<td>18.780349</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>High Density</td>
<td>34.27685</td>
<td>11.795288</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>35.77036</td>
<td>13.719679</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>34.82556</td>
<td>14.639549</td>
<td>103</td>
</tr>
<tr>
<td>Salivary Alpha-Amylase</td>
<td>Low Density</td>
<td>264.12665</td>
<td>113.646614</td>
<td>26</td>
</tr>
<tr>
<td>Post-Stressor</td>
<td>Medium Density</td>
<td>264.31312</td>
<td>94.834859</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>High Density</td>
<td>288.37196</td>
<td>105.227796</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>273.39200</td>
<td>78.893380</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>272.54277</td>
<td>98.222809</td>
<td>103</td>
</tr>
<tr>
<td>Salivary Alpha-Amylase</td>
<td>Low Density</td>
<td>193.22615</td>
<td>97.738953</td>
<td>26</td>
</tr>
<tr>
<td>Post-Treatment</td>
<td>Medium Density</td>
<td>119.29096</td>
<td>69.130889</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>High Density</td>
<td>175.00154</td>
<td>90.805719</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>218.85312</td>
<td>76.657658</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>176.18265</td>
<td>90.896209</td>
<td>103</td>
</tr>
</tbody>
</table>
Figure 50: Stress Reduction using Salivary Alpha-Amylase levels - 4 Treatment Groups

The Box’s test of Equality of Covariance Matrices confirms that the observed covariance matrices of the dependent variables, i.e., the salivary alpha-amylase levels are equal across the control and the three treatment groups.

<table>
<thead>
<tr>
<th>Box's Test of Equality of Covariance Matricesa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Box’s M</td>
</tr>
<tr>
<td>F</td>
</tr>
<tr>
<td>df1</td>
</tr>
<tr>
<td>df2</td>
</tr>
<tr>
<td>Sig.</td>
</tr>
</tbody>
</table>

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + EXP_Group
   Within Subjects Design: Time
Wilk’s Lambda values illustrate that there is a significant difference ($p<0.05$) in the salivary alpha-amylase levels of the participants across the three time points when the sample was collected, for all four experimental groups and the effect size is large at 0.546 (Table 22). The results also show a 50.3% change in salivary alpha amylase levels across time and group combination which is a significant difference ($p<0.05$). However, no significant difference was found between genders or race.

Table 22: Analysis of Salivary Alpha-Amylase levels between 4 Treatment Groups

<table>
<thead>
<tr>
<th>Effect</th>
<th>Pillai’s Trace</th>
<th>Wilks’ Lambda</th>
<th>Hotelling’s Trace</th>
<th>Roy’s Largest Root</th>
<th>Partial Eta Squared</th>
<th>Noncent. Parameter</th>
<th>Observed Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>.546</td>
<td>.454</td>
<td>1.201</td>
<td>1.201</td>
<td>.546</td>
<td>115.309</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>57.655b</td>
<td>2.000</td>
<td>2.000</td>
<td>.000</td>
<td>.546</td>
<td>115.309</td>
</tr>
<tr>
<td></td>
<td>Hypothesis df</td>
<td>96.000</td>
<td>96.000</td>
<td>96.000</td>
<td>.000</td>
<td>.546</td>
<td>115.309</td>
</tr>
<tr>
<td></td>
<td>Error df</td>
<td>57.655b</td>
<td>96.000</td>
<td>96.000</td>
<td>.000</td>
<td>.546</td>
<td>115.309</td>
</tr>
<tr>
<td></td>
<td>Sig.</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.546</td>
<td>115.309</td>
</tr>
<tr>
<td>Time * EXP_Group</td>
<td>.763</td>
<td>.247</td>
<td>3.009</td>
<td>2.995</td>
<td>.381</td>
<td>119.629</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>19.938</td>
<td>47.637</td>
<td>96.848c</td>
<td>.234b</td>
<td>199.4325</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>Hypothesis df</td>
<td>6.000</td>
<td>6.000</td>
<td>3.000</td>
<td>.000</td>
<td>.381</td>
<td>119.629</td>
</tr>
<tr>
<td></td>
<td>Error df</td>
<td>194.000</td>
<td>192.000</td>
<td>97.000</td>
<td>.000</td>
<td>.503</td>
<td>194.325</td>
</tr>
<tr>
<td></td>
<td>Sig.</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.601</td>
<td>285.820</td>
</tr>
<tr>
<td>Time * GENDER</td>
<td>.005</td>
<td>.995</td>
<td>.005</td>
<td>.005</td>
<td>.468</td>
<td>.468</td>
<td>.086</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>.234b</td>
<td>.234b</td>
<td>.234b</td>
<td>.792</td>
<td>.468</td>
<td>.086</td>
</tr>
<tr>
<td></td>
<td>Hypothesis df</td>
<td>2.000</td>
<td>2.000</td>
<td>2.000</td>
<td>.005</td>
<td>.468</td>
<td>.086</td>
</tr>
<tr>
<td></td>
<td>Error df</td>
<td>96.000</td>
<td>96.000</td>
<td>96.000</td>
<td>.005</td>
<td>.468</td>
<td>.086</td>
</tr>
<tr>
<td></td>
<td>Sig.</td>
<td>.792</td>
<td>.792</td>
<td>.792</td>
<td>.005</td>
<td>.468</td>
<td>.086</td>
</tr>
<tr>
<td>Time * RACE</td>
<td>.054</td>
<td>.946</td>
<td>.057</td>
<td>.057</td>
<td>.543</td>
<td>.532</td>
<td>.532</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>2.756b</td>
<td>2.756b</td>
<td>2.756b</td>
<td>.069</td>
<td>.5513</td>
<td>.532</td>
</tr>
<tr>
<td></td>
<td>Hypothesis df</td>
<td>2.000</td>
<td>2.000</td>
<td>2.000</td>
<td>.069</td>
<td>.5513</td>
<td>.532</td>
</tr>
<tr>
<td></td>
<td>Error df</td>
<td>96.000</td>
<td>96.000</td>
<td>96.000</td>
<td>.069</td>
<td>.5513</td>
<td>.532</td>
</tr>
<tr>
<td></td>
<td>Sig.</td>
<td>.069</td>
<td>.069</td>
<td>.069</td>
<td>.054</td>
<td>.5513</td>
<td>.532</td>
</tr>
</tbody>
</table>

a. Design: Intercept + EXP_Group + GENDER + RACE
Within Subjects Design: Time
b. Exact statistic
c. The statistic is an upper bound on F that yields a lower bound on the significance level.
d. Computed using alpha =

The Mauchly’s Test of Sphericity is significant (p<0.05) indicating that there are significant differences between the variance of differences and the condition for sphericity has not been met (Table 23).

Table 23: Mauchly’s Test of Sphericity

<table>
<thead>
<tr>
<th>Within Subjects Effect</th>
<th>Mauchly’s W</th>
<th>Approx. Chi-Square</th>
<th>df</th>
<th>Sig.</th>
<th>Epsilon</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>.206</td>
<td>151.701</td>
<td>2</td>
<td>.000</td>
<td>.557</td>
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<td>.588</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.500</td>
</tr>
</tbody>
</table>

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a. Design: Intercept + EXP_Group
   Within Subjects Design: Time
b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Because the assumption of sphericity was violated, Greenhouse-Geisser values are used to calculate the effect size. Results show that there is a significant difference (p<0.05) in the salivary alpha-amylase levels of the participants across the three time points when the sample was collected, for all the four treatment groups. Results reveal a statistically significant main effect of time on the alpha-amylase levels, F(2, 194)= 67.202, p<0.05 and a significant interaction between of time and experimental group, F(6,194)=6.43,
$p<0.05$ (Table 24). Neither gender nor race caused any variation in the salivary alpha-amylase activity within the four experimental groups.

A linear and quadratic trend appears from the tests of within-subjects contrast across three time points and time-group interaction (Table 25).
### Table 24: Analysis of Salivary Alpha-Amylase levels across Gender and Ethnicity

**Tests of Within-Subjects Effects**

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
<th>Noncent. Parameter</th>
<th>Observed Powera</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sphericity Assumed</td>
<td>308771.272</td>
<td>2</td>
<td>154385.636</td>
<td>67.202</td>
<td>.000</td>
<td>.409</td>
<td>134.404</td>
<td>1.000</td>
</tr>
<tr>
<td>Greenhouse-Geisser</td>
<td>308771.272</td>
<td>1.117</td>
<td>276978.770</td>
<td>67.202</td>
<td>.000</td>
<td>.409</td>
<td>74.915</td>
<td>1.000</td>
</tr>
<tr>
<td>Huynh-Feldt</td>
<td>308771.272</td>
<td>1.177</td>
<td>262417.129</td>
<td>67.202</td>
<td>.000</td>
<td>.409</td>
<td>79.073</td>
<td>1.000</td>
</tr>
<tr>
<td>Lower-bound</td>
<td>308771.272</td>
<td>1.000</td>
<td>308771.272</td>
<td>67.202</td>
<td>.000</td>
<td>.409</td>
<td>67.202</td>
<td>1.000</td>
</tr>
<tr>
<td><strong>Time * EXP_Group</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sphericity Assumed</td>
<td>88653.277</td>
<td>6</td>
<td>14775.546</td>
<td>6.432</td>
<td>.000</td>
<td>.166</td>
<td>38.589</td>
<td>.999</td>
</tr>
<tr>
<td>Greenhouse-Geisser</td>
<td>88653.277</td>
<td>3.344</td>
<td>26508.377</td>
<td>6.432</td>
<td>.000</td>
<td>.166</td>
<td>21.509</td>
<td>.976</td>
</tr>
<tr>
<td>Huynh-Feldt</td>
<td>88653.277</td>
<td>3.530</td>
<td>25114.748</td>
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<td>3.000</td>
<td>29551.092</td>
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<td><strong>Time * GENDER</strong></td>
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<td></td>
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<tr>
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<td>615.773</td>
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<td>.765</td>
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<tr>
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a. Computed using alpha =
Table 25: Trend Analysis of Salivary Alpha-Amylase levels - 4 Treatment Groups

**Tests of Within-Subjects Contrasts**

<table>
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<tr>
<th>Source</th>
<th>Time</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
<th>Noncent. Parameter</th>
<th>Observed Power</th>
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<td>Time</td>
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<td>1</td>
<td>121657.956</td>
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<td>.000</td>
<td>.319</td>
<td>45.522</td>
<td>1.000</td>
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<td>Quadratic</td>
<td>187113.316</td>
<td>1</td>
<td>187113.316</td>
<td>97.345</td>
<td>.000</td>
<td>.501</td>
<td>97.345</td>
<td>1.000</td>
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<tr>
<td>Time * EXP_Group</td>
<td>Linear</td>
<td>66834.571</td>
<td>3</td>
<td>22278.190</td>
<td>8.336</td>
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<td>.205</td>
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<td>.105</td>
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<td>1</td>
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<td>.002</td>
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<td>.391</td>
<td>.095</td>
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</table>

a. Computed using alpha =
Table 26: Test for Equality of Variance

<table>
<thead>
<tr>
<th>Levene's Test of Equality of Error Variances&lt;sup&gt;a&lt;/sup&gt;</th>
<th>F</th>
<th>df1</th>
<th>df2</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salivary Alpha-Amylase Pre-Stressor</td>
<td>.778</td>
<td>3</td>
<td>99</td>
<td>.509</td>
</tr>
<tr>
<td>Salivary Alpha-Amylase Post-Stressor</td>
<td>1.213</td>
<td>3</td>
<td>99</td>
<td>.309</td>
</tr>
<tr>
<td>Salivary Alpha-Amylase Post-Treatment</td>
<td>1.034</td>
<td>3</td>
<td>99</td>
<td>.381</td>
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</tbody>
</table>

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

<sup>a</sup> Design: Intercept + EXP_Group + GENDER + RACE
Within Subjects Design: Time

To examine the difference in the recovery from stress between the four experimental groups, planned within-subjects comparisons are employed. Table 26 shows the means and standard deviations of the salivary alpha-amylase levels at different time points as a function of the experimental group categorization and also shows the mean differences between the group values. Assumption testing indicated no gross violation of assumptions.

No statistically significant difference in the mean values of salivary alpha-amylase levels is noted in at the pre-stressor and post-stressor time points (Table 26). This indicates that all the participants started the experiment at similar baseline or pre-stressor alpha-amylase levels and that the stress induction task induced uniform stress among participants irrespective of which treatment group they were assigned to. For the post-treatment measurement, the medium density vegetation group is significantly different (<i>p</i>&lt;0.05) from the low and high vegetation density group as well as the control group.
Turkey HSD Post Hoc analysis of post-nature-treatment measures shows a statistically significant decrease \((p< 0.05)\) in the salivary alpha-amylase levels in the medium density group as compared to the control group (Table 27). The mean decrease in salivary alpha-amylase levels of medium density vegetation group as compared to control group is 94.65 with a 95% confidence interval for the difference between the means of 41.46 to 147.83.

*Figure 51: Salivary Alpha-Amylase Responses to Stressor and Treatment: 4 Treatment Groups*
Table 27: Post-Hoc Analysis of Salivary Alpha-Amylase levels across time and between groups

Pairwise Comparisons

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>(I) Experimental Group/Category</th>
<th>(J) Experimental Group/Category</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval for Difference</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
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</thead>
<tbody>
<tr>
<td>Salivary Alpha- Amylase Pre-Stressor</td>
<td>Low Density</td>
<td>Medium Density</td>
<td>-5.057</td>
<td>4.831</td>
<td>.299</td>
<td>-14.682</td>
<td>4.569</td>
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<tr>
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<td>High Density</td>
<td>-9.43</td>
<td>5.119</td>
<td>.854</td>
<td>-11.142</td>
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<tr>
<td></td>
<td>Control</td>
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<td>4.786</td>
<td>.583</td>
<td>-12.177</td>
<td>6.895</td>
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<td></td>
<td>Medium Density</td>
<td>Low Density</td>
<td>5.057</td>
<td>4.831</td>
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<td>-4.569</td>
<td>14.682</td>
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<td>High Density</td>
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<td>4.891</td>
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<td>Low Density</td>
<td>.943</td>
<td>5.119</td>
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<td>Medium Density</td>
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<td>5.632</td>
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<tr>
<td></td>
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<td>-1.699</td>
<td>4.847</td>
<td>.727</td>
<td>-11.356</td>
<td>7.959</td>
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</tr>
<tr>
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<td>Control</td>
<td>Low Density</td>
<td>2.641</td>
<td>4.786</td>
<td>.583</td>
<td>-6.895</td>
<td>12.177</td>
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<tr>
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<td>Medium Density</td>
<td>Low Density</td>
<td>3.527</td>
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<td>High Density</td>
<td>Low Density</td>
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<td>.727</td>
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<td>11.356</td>
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<td>32.710</td>
<td>.815</td>
<td>-57.483</td>
<td>72.870</td>
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<td>Medium Density</td>
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<td>34.985</td>
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<td>-41.142</td>
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<tr>
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<td>Control</td>
<td>Low Density</td>
<td>17.970</td>
<td>28.126</td>
<td>.525</td>
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<td>.525</td>
<td>-38.072</td>
<td>74.013</td>
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</table>

Based on estimated marginal means
* The mean difference is significant at the
  a. An estimate of the modified population marginal mean (I).
  b. An estimate of the modified population marginal mean (J).
d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

The mean decrease in stress levels in the medium density group as compared to the low density of vegetation group is 76.67 with a 95% confidence interval for the difference between the means of 20.11 to 133.24. The decrease in stress of medium density group is significant as compared to the low density vegetation group ($p< 0.05$) and almost significant as compared to the high density vegetation group (Table 27). In case of the medium and high density of vegetation groups, the mean decrease is 58.29 with a 95% confidence interval for the difference between the means of 0.95 to 115.50.

Analysis of the gender and race/ethnicity differences shows no influence of gender or race on recovery from stress as measured through salivary alpha-amylase levels (Table 28).

**Table 28: Analysis of Salivary Alpha-Amylase levels across Gender**

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Participant's Gender</th>
<th>Mean</th>
<th>Std. Error</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
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</thead>
<tbody>
<tr>
<td>Salivary Alpha-Amylase Pre-Stressor</td>
<td>MALE</td>
<td>35.099</td>
<td>2.249</td>
<td>30.619</td>
<td>39.580</td>
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<td>FEMALE</td>
<td>33.252</td>
<td>2.649</td>
<td>27.973</td>
<td>38.531</td>
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<tr>
<td>Salivary Alpha-Amylase Post-Stressor</td>
<td>MALE</td>
<td>266.433</td>
<td>15.368</td>
<td>235.811</td>
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<td>FEMALE</td>
<td>259.738</td>
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<td>13.214</td>
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<td>FEMALE</td>
<td>162.070</td>
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</table>

a. Based on modified population marginal mean.
### Pairwise Comparisons

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>(I) Participant’s Gender</th>
<th>(J) Participant’s Gender</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval for Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salivary Alpha-Amylase Pre-Stressor</td>
<td>MALE</td>
<td>FEMALE</td>
<td>1.847&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>3.475</td>
<td>.597</td>
<td>-5.077 to 8.771</td>
</tr>
<tr>
<td>Salivary Alpha-Amylase Post-Stressor</td>
<td>MALE</td>
<td>FEMALE</td>
<td>-1.847&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>3.475</td>
<td>.597</td>
<td>-8.771 to 5.077</td>
</tr>
<tr>
<td>Salivary Alpha-Amylase Post-Treatment</td>
<td>MALE</td>
<td>FEMALE</td>
<td>6.695&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>23.750</td>
<td>.779</td>
<td>-40.628 to 54.018</td>
</tr>
<tr>
<td>Salivary Alpha-Amylase Post-Treatment</td>
<td>FEMALE</td>
<td>MALE</td>
<td>-6.695&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>23.750</td>
<td>.779</td>
<td>-54.018 to 40.628</td>
</tr>
</tbody>
</table>

Based on estimated marginal means
- a. An estimate of the modified population marginal mean (I).
- b. An estimate of the modified population marginal mean (J).
- c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

![Figure 52: Salivary Alpha-Amylase Responses to Stressor and Treatment by Gender: 4 Treatment Groups](image)
Table 29: Descriptive Statistics of Salivary Alpha-Amylase levels across Race/Ethnicity

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Race/Ethnicity</th>
<th>Mean</th>
<th>Std. Error</th>
<th>95% Confidence Interval Lower Bound</th>
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</thead>
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<td></td>
<td></td>
</tr>
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<td>Salivary Alpha-Amylase Pre-</td>
<td>White/ Non-Hispanic</td>
<td>35.066</td>
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<td>African American/ Black</td>
<td>43.214</td>
<td>4.130</td>
<td>34.984</td>
<td>51.444</td>
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<tr>
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<td>31.097</td>
<td>2.811</td>
<td>25.495</td>
<td>36.699</td>
</tr>
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<td>Hispanic/Latino</td>
<td>29.062</td>
<td>4.635</td>
<td>19.826</td>
<td>38.298</td>
</tr>
<tr>
<td>Salivary Alpha-Amylase Post-</td>
<td>White/ Non-Hispanic</td>
<td>274.695</td>
<td>15.763</td>
<td>243.287</td>
<td>306.104</td>
</tr>
<tr>
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<tr>
<td></td>
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<td>Salivary Alpha-Amylase Post-</td>
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<tr>
<td>Treatment</td>
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<td>24.274</td>
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<td>27.241</td>
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</table>

a. Based on modified population marginal mean.

Table 30: Analysis of Salivary Alpha-Amylase levels across Race/Ethnicity

<table>
<thead>
<tr>
<th>Pairwise Comparisons</th>
<th>Dependent Variable (I) Race/Ethnicity</th>
<th>(J) Race/Ethnicity</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval for Difference Lower Bound</th>
<th>95% Confidence Interval for Difference Upper Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>African American/ Black</td>
<td>-8.148</td>
<td>4.731</td>
<td>.089</td>
<td>-17.574</td>
<td>1.278</td>
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<td>Asian</td>
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<td>5.177</td>
<td>.250</td>
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<tr>
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<td>White/ Non-Hispanic</td>
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<td>4.731</td>
<td>.089</td>
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<td>-1.278</td>
<td>17.574</td>
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<tr>
<td></td>
<td>Asian</td>
<td>12.116*</td>
<td>4.996</td>
<td>.018</td>
<td></td>
<td>2.161</td>
<td>22.072</td>
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<td>Hispanic/Latino</td>
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<td>Hispanic/Latino</td>
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<td>-2.161</td>
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<td>-16.320</td>
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<td>.708</td>
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<tr>
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<td>107.565</td>
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</tr>
<tr>
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<td>Asian</td>
<td>40.425</td>
<td>34.149</td>
<td>.240</td>
<td>-27.619</td>
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</tr>
<tr>
<td></td>
<td>Hispanic/Latino</td>
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<td>42.434</td>
<td>.085</td>
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<tr>
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<td>65.700</td>
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<td>24.854</td>
<td>.517</td>
<td>-65.700</td>
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<td>34.149</td>
<td>.240</td>
<td>-108.468</td>
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<tr>
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<td>.366</td>
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<tr>
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<td>42.434</td>
<td>.085</td>
<td>-158.711</td>
<td>10.392</td>
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<td>37.053</td>
<td>.366</td>
<td>-107.565</td>
<td>40.996</td>
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<td></td>
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<tr>
<td>Salivary Alpha- Amylase Post-Treatment</td>
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<td>27.801</td>
<td>.745</td>
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<td>29.363</td>
<td>.315</td>
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<tr>
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<td>36.487</td>
<td>.093</td>
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<td>29.363</td>
<td>.315</td>
<td>-88.237</td>
<td>28.778</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>32.408</td>
<td>31.860</td>
<td>.312</td>
<td>-31.075</td>
<td>95.891</td>
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<tr>
<td>Hispanic/Latino</td>
<td>-53.077</td>
<td>30.427</td>
<td>.085</td>
<td>-113.704</td>
<td>7.550</td>
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<td>Salivary Alpha- Amylase Post-Treatment</td>
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<td>36.487</td>
<td>.093</td>
<td>-134.840</td>
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<td>-32.408</td>
<td>31.860</td>
<td>.312</td>
<td>-95.891</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Based on estimated marginal means

* The mean difference is significant at the
  a. An estimate of the modified population marginal mean (J).
  b. An estimate of the modified population marginal mean (I).
  d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).
Figure 53: Differences in Stress-Responses between 4 Treatment Groups by Gender
Figure 54: Differences in Stress-Responses between 4 Treatment Groups by Race/Ethnicity
5.6 Analysis of the Semi-Structured Interview Responses

The responses from the semi-structured interview were analyzed following the steps as described by Sommer and Sommer (1997). First, all the recorded interviews were transcribed carefully. Then, the final data set of interview responses was skimmed and a set of coding categories were generated in which the responses could be classified. The responses were arranged into the relevant categories. The responses were also categorized as per the intervention group that the participants were assigned to (namely low, medium and high vegetation density group and the control group). Coded responses were quantified as per the number the number of times each category was mentioned in the responses. Frequency and percentages, based on the number of times a response referred to a category was generated.

Table 31 represents the frequencies of responses to the questions of the semi-structured interview categorized based on the image that the participant experienced. Responses only from participants that had nature exposure (n=78) are included in this analysis, where the participants were asked to describe the urban park image that they experienced and elements of the park were discussed. Participants who were in the control group only answered questions about the healing or therapeutic spaces they prefer to spend time in when in a stressed state of mind.
Table 31: Semi-Structured Interview Responses

<table>
<thead>
<tr>
<th>Structured Interview Questions</th>
<th>Treatment Group 1: Low Density</th>
<th>Treatment Group 2: Medium Density</th>
<th>Treatment Group 3: High Density</th>
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<tr>
<td></td>
<td>(N=26) Number</td>
<td>Percent</td>
<td>(N=26) Number</td>
</tr>
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<td><strong>Question 1: Elements described</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trees</td>
<td>4</td>
<td>15.4</td>
<td>23</td>
</tr>
<tr>
<td>Grass/ ground cover</td>
<td>21</td>
<td>80.8</td>
<td>8</td>
</tr>
<tr>
<td>Landform/ Slope</td>
<td>18</td>
<td>69.2</td>
<td>16</td>
</tr>
<tr>
<td>Water body</td>
<td>25</td>
<td>96.2</td>
<td>24</td>
</tr>
<tr>
<td>Rocks/ Boulders</td>
<td>23</td>
<td>88.5</td>
<td>18</td>
</tr>
<tr>
<td>Pathways</td>
<td>3</td>
<td>11.5</td>
<td>15</td>
</tr>
<tr>
<td>Bridge</td>
<td>17</td>
<td>65.4</td>
<td>14</td>
</tr>
<tr>
<td>Tunnel</td>
<td>0</td>
<td>0.0</td>
<td>11</td>
</tr>
<tr>
<td>Bench/ Place to sit</td>
<td>0</td>
<td>0.0</td>
<td>13</td>
</tr>
<tr>
<td>Presence of other People</td>
<td>1</td>
<td>3.8</td>
<td>9</td>
</tr>
<tr>
<td>Built structure in the background</td>
<td>3</td>
<td>11.5</td>
<td>14</td>
</tr>
<tr>
<td>Skyline</td>
<td>15</td>
<td>57.7</td>
<td>8</td>
</tr>
<tr>
<td><strong>Question 2: Elements Liked</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Trees</td>
<td>2</td>
<td>7.7</td>
<td>23</td>
</tr>
<tr>
<td>Grass/ ground cover</td>
<td>4</td>
<td>15.4</td>
<td>8</td>
</tr>
<tr>
<td>Landform/ Slope</td>
<td>6</td>
<td>23.1</td>
<td>16</td>
</tr>
<tr>
<td>Water body</td>
<td>19</td>
<td>73.1</td>
<td>21</td>
</tr>
<tr>
<td>Pathways</td>
<td>0</td>
<td>0.0</td>
<td>12</td>
</tr>
<tr>
<td>Bridge</td>
<td>0</td>
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<td>6</td>
</tr>
<tr>
<td>Tunnel</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>Bench/ Place to sit</td>
<td>0</td>
<td>0.0</td>
<td>3</td>
</tr>
<tr>
<td>Presence of other People</td>
<td>0</td>
<td>0.0</td>
<td>8</td>
</tr>
<tr>
<td>Skyline</td>
<td>6</td>
<td>23.1</td>
<td>4</td>
</tr>
<tr>
<td><strong>Question 3: Elements that helped feel better</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trees</td>
<td>2</td>
<td>7.7</td>
<td>24</td>
</tr>
<tr>
<td>Grass/ ground cover</td>
<td>3</td>
<td>11.5</td>
<td>8</td>
</tr>
<tr>
<td>Landform/ Slope</td>
<td>0</td>
<td>0.0</td>
<td>18</td>
</tr>
<tr>
<td>Water body</td>
<td>16</td>
<td>61.5</td>
<td>22</td>
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### Question 4: Elements disliked or that made feel worse

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<th>10</th>
<th>38.5</th>
<th>0</th>
<th>0.0</th>
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</thead>
<tbody>
<tr>
<td>Pathways</td>
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<td>0.0</td>
<td>10</td>
<td>38.5</td>
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<td>0.0</td>
</tr>
<tr>
<td>Bridge</td>
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<td>0.0</td>
<td>5</td>
<td>19.2</td>
<td>4</td>
<td>15.4</td>
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<td>Presence of other People</td>
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<td>0.0</td>
<td>14</td>
<td>53.8</td>
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<td>0.0</td>
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<tr>
<td>Skyline</td>
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<td>0.0</td>
<td>3</td>
<td>11.5</td>
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</table>

### Question 5: How appealing was the WATER?

<table>
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<tr>
<th>Appealing Level</th>
<th>5= Very Appealing</th>
<th>4= Somewhat Appealing</th>
<th>3= Neutral</th>
<th>2= Slightly Appealing</th>
<th>1= Not Appealing at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>6</td>
<td>23.1</td>
<td>2</td>
<td>7.7</td>
<td>4</td>
</tr>
<tr>
<td>No</td>
<td>20</td>
<td>76.9</td>
<td>24</td>
<td>92.3</td>
<td>22</td>
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</table>

### Question 7: How appealing was the LANDFORM?

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<th>4= Somewhat Appealing</th>
<th>3= Neutral</th>
<th>2= Slightly Appealing</th>
<th>1= Not Appealing at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>2</td>
<td>7.7</td>
<td>8</td>
<td>30.8</td>
<td>5</td>
</tr>
<tr>
<td>No</td>
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<td>46.2</td>
<td>12</td>
<td>46.2</td>
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### Question 8: Preferred different form of Landform

<table>
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<tr>
<th>Preferred Form</th>
<th>Yes</th>
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<th>6</th>
<th>23.1</th>
<th>12</th>
<th>46.2</th>
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</thead>
<tbody>
<tr>
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<td>69.2</td>
<td>6</td>
<td>23.1</td>
<td>12</td>
<td>46.2</td>
</tr>
<tr>
<td>No</td>
<td>8</td>
<td>30.8</td>
<td>20</td>
<td>76.9</td>
<td>14</td>
<td>53.8</td>
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</table>

### Question 9: How appealing was the VEGETATION?

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<th>5= Very Appealing</th>
<th>4= Somewhat Appealing</th>
<th>3= Neutral</th>
<th>2= Slightly Appealing</th>
<th>1= Not Appealing at all</th>
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<tr>
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<td>46.2</td>
<td>4</td>
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<td>No</td>
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<td>7.7</td>
<td>10</td>
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<td>6</td>
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### Question 10: Preferred different form of Vegetation

<table>
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<th>8</th>
<th>30.8</th>
<th>21</th>
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<td>92.3</td>
<td>8</td>
<td>30.8</td>
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<td>80.8</td>
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<tr>
<td>No</td>
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<td>7.7</td>
<td>18</td>
<td>69.2</td>
<td>5</td>
<td>19.2</td>
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### Question 11: Include additional elements that may have restorative properties

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<th>12</th>
<th>46.2</th>
<th>6</th>
<th>23.1</th>
</tr>
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<td>0.0</td>
<td>4</td>
<td>15.4</td>
<td>3</td>
<td>11.5</td>
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<td>Sculptures</td>
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<td>8</td>
<td>30.8</td>
<td>10</td>
<td>38.5</td>
</tr>
<tr>
<td>More flowers/ color</td>
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<td>46.2</td>
<td>6</td>
<td>23.1</td>
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<td>0.0</td>
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<tr>
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<td>7.7</td>
<td>0</td>
<td>0.0</td>
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<td>11.5</td>
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<td>26.9</td>
<td>6</td>
<td>23.1</td>
</tr>
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<td>More levels/ slopes</td>
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<td>7.7</td>
<td>12</td>
<td>46.2</td>
<td>12</td>
<td>46.2</td>
</tr>
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<td>30.8</td>
<td>9</td>
<td>34.6</td>
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<td>1</td>
<td>3.8</td>
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<td>0</td>
<td>0.0</td>
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<td>69.2</td>
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</tbody>
</table>

### Question 12: Exclude any elements that may help restoration

<table>
<thead>
<tr>
<th>Element</th>
<th>0</th>
<th>0.0</th>
<th>0</th>
<th>0.0</th>
<th>18</th>
<th>69.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less trees</td>
<td>6</td>
<td>23.1</td>
<td>4</td>
<td>15.4</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Built structure from the background</td>
<td>4</td>
<td>15.4</td>
<td>3</td>
<td>11.5</td>
<td>4</td>
<td>15.4</td>
</tr>
<tr>
<td>Bridge</td>
<td>12</td>
<td>46.2</td>
<td>0</td>
<td>0.0</td>
<td>2</td>
<td>7.7</td>
</tr>
<tr>
<td>Rocks/ Boulders</td>
<td>8</td>
<td>30.8</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
Within the low density vegetation group (N=26), 92.3% of the participants indicated that they would like different form of vegetation. 46.2% of the participants would have liked to see more grass or ground cover and 84.6% of the participants would have preferred more trees and shrubs. 53.8% of the participants did not find the tress cover appealing at all, while only 7.7% of the participants found the vegetation appealing. 34.6% of the participants expressed that the water feature was very appealing while 46.2% of the participants found the water somewhat appealing. Among the participants who experienced the medium density image (N=26), 88.5% enjoyed the trees and 30.8% liked the grass and the groundcover. In terms of elements that helped with restoration, 92.3% of the participants talked about trees, 30.8% talked about ground cover, 69.2% mentioned slopes and landform and 84.6% of the participants mentioned the presence of water to be effective. None of the natural elements made the participants feel worse in any way, apart from the existing bridge and pathway in the distance that 7.7% of the participants found not so pleasant. 46.2% of the participants expressed need for additional places or benches to sit and enjoy the park. 30.8% of the participants mentioned that addition of more flowers and colors would make the park more appealing. From the participants who experienced the high density image (N=26), 100% of them described the existing vegetation in their responses, though only 38.5% expressed liking it. On the contrary, 53.8% of the participants talked about feeling overwhelmed and lost by the amount of vegetation and mentioned lack of control or visual coherence and even fear in connection to the vegetation density. 80.8 % of the
participants voiced preference for different kind and amount of vegetation and 69.2% indicated that fewer trees would have helped with better restoration.

The presence of water feature in the urban park was consistently appreciated across all intervention groups irrespective of the amount of vegetation, where an average 35.9% of the participants found the water feature very appealing and 50.3% found it somewhat appealing. Similarly, the landform was also equally valued across the three treatment groups, with lower preference (15.4%) in the low vegetation group and higher percentages of visual appeal in the medium (46.2%) and high (30.8%) vegetation groups.

The participants also ranked all three urban park images based on their preference. The treatment groups participants were exposed to one of the three urban park images differing in the amount of vegetation in each image and the control group saw an image of a parking deck. The control group image ranked the lowest in terms of preference and was labeled as ‘too structured’ with nothing much of interest to grab the attention of the participants or provide any form of restoration. The low vegetation density image was second in rank in the ‘low preference’ category owing to the large expanses of undifferentiated land covers with little to focus on. The participants were not enticed to explore the setting as it lacked any interesting points of focus and was labeled as ‘too
boring’. Next up in ranking was the dense vegetation image. Table 32 and Figure 50 show the ranking of the images based on the participant preferences.

Table 32: Vegetation Density Preference from Images

<table>
<thead>
<tr>
<th>How appealing is the images?</th>
<th>Valid</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very Appealing</td>
<td>Somewhat Appealing</td>
<td>Not appealing at all</td>
<td>Total</td>
</tr>
<tr>
<td>Low Density</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>0</td>
<td>17</td>
<td>86</td>
<td>103</td>
</tr>
<tr>
<td>Percent</td>
<td>0</td>
<td>16.5</td>
<td>83.5</td>
<td>100.0</td>
</tr>
<tr>
<td>Medium Density</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>78</td>
<td>25</td>
<td>3</td>
<td>103</td>
</tr>
<tr>
<td>Percent</td>
<td>75.7</td>
<td>21.4</td>
<td>2.9</td>
<td>100.0</td>
</tr>
<tr>
<td>High Density</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>25</td>
<td>61</td>
<td>17</td>
<td>103</td>
</tr>
<tr>
<td>Percent</td>
<td>24.3</td>
<td>59.2</td>
<td>16.5</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Figure 55: Vegetation Density Preference from Images
The interview responses were also categorized based on the emerging themes from the responses. Table 32 shows the categorization of the responses from participants within each treatment group. The presence of vegetation and water element was a recurring theme along with the possibility of activity and presence of people. 46.2% of the participants in the low density group, 92.30% of the participants in the medium density group and 100% of the participants in the high density group talked about the presence of trees and vegetation that provided biophilic connection. Similarly, 96.2% of the low density group, 84.62% of the medium density group and 84.62% of the high density group expressed that presence of water element was associated with stress recovery. 65.38% of the participants in the medium density group associated presence of other people in the park with a feeling of engagement and social interaction. 88.47% of the participants in the medium density group indicated that the complexity of the park design suggested potential exploration and aroused mystery, while 65.38% of the participants in the high density group felt that the complexity of the image was too overpowering and induced a feeling of fear and less control. The presence of the built form in the vicinity was also described as comforting and reassuring.
Table 33: Themes from Semi-Structured Interview Responses

<table>
<thead>
<tr>
<th>Response Coding Categories:</th>
<th>Treatment Group 1: Low Density (N=26)</th>
<th>Treatment Group 2: Medium Density (N=26)</th>
<th>Treatment Group 3: High Density (N=26)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Percent</td>
<td>Number</td>
</tr>
<tr>
<td>Question 1: Elements described</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of Vegetation- Biophilia</td>
<td>12</td>
<td>46.2</td>
<td>24</td>
</tr>
<tr>
<td>Presence of Water- Biophilia</td>
<td>25</td>
<td>96.2</td>
<td>22</td>
</tr>
<tr>
<td>Possibility of Activity- Control</td>
<td>6</td>
<td>23.08</td>
<td>18</td>
</tr>
<tr>
<td>Enclosure- Feeling of Safety</td>
<td>12</td>
<td>46.2</td>
<td>16</td>
</tr>
<tr>
<td>Presence of People- Engagement</td>
<td>2</td>
<td>7.7</td>
<td>17</td>
</tr>
<tr>
<td>Complexity of Design- Exploration</td>
<td>6</td>
<td>23.08</td>
<td>23</td>
</tr>
<tr>
<td>Urban Form in the vicinity- Reassurance</td>
<td>8</td>
<td>30.08</td>
<td>14</td>
</tr>
</tbody>
</table>
CHAPTER 6: DISCUSSIONS

This study investigates the amount of green exposure that is most beneficial for recovery from acute stress along with the other design elements of the urban parks that foster restoration. Landscape features in the form of vegetation densities (low, medium and high) were used as the independent variables for this investigation. The outcome variable of stress level was measured using self-reported STAI scores and physiological biomarkers including salivary alpha-amylase and salivary cortisol. The change in stress levels was examined as it related to the vegetation densities across three time points when the saliva sample was collected in each of the four intervention groups (three nature treatment groups and one control group). Age group of the participants was limited between 18 and 35 years to minimize the differences in the basal salivary alpha-amylase and salivary cortisol levels. The time of the day when the saliva samples were collected was controlled for to limit the diurnal changes in the salivary alpha-amylase and salivary cortisol levels. This section integrates the results of the quasi-experiment and the findings from the structured interviews into a framework for evaluating the design of urban parks in association with recovery from acute stress. Incorporating the right amount of vegetation along with the best fitted design features into the everyday ordinary natural environments within the resolute built urban environment is one approach to maximizing the benefit of publically accessible green spaces for urban residents. These carefully designed spaces can physically disrupt the highly structured urban form. They
can also promote restoration from urban stressors and provide stimulating experiences.

The research questions of this study are revisited and answered below.

6.1 Quantitative Findings

Quantitative analysis of the stress levels measured using self-reported STAI scores and salivary alpha-amylase and salivary cortisol levels suggest the findings as described below.

6.1.1 Nature exposure aids faster recovery from stress

Research Question 1:

Is brief exposure to nature enough to produce a significant calming effect from a stressful event? What is the effect of nature on acute stress recovery from a stressful event?

Analysis of the data indicates that there is statistically significant difference in the stress levels of people recovering from a stressful event who are exposed to some kind of nature during their recovery period as compared to those who do not have any nature exposure, even when the exposure lasts only for a brief amount of time. In this study, even the participants who experienced the lowest density of vegetation image also had lower levels of stress post-treatment as compared to the control group of participants who had no nature exposure. The levels of stress as measured from salivary alpha-amylase increased by over 300% ($d = 3.19$) from baseline to post-stressor. Treatment group (low,
medium and high density combined) participants showed a 110% (d= 1.10) reduction in stress level after treatment as compared to the control group that recovered by only by 70% (d= 0.70) as measured from salivary alpha-amylase levels.

6.1.2 Levels of Stress change with changes in Vegetation Densities

Research Question 2:
When recovering from a stressful event, what amount of vegetation density produces maximum calming effect or fosters fastest stress recovery?

During the recovery period, what is the difference in the stress reduction among participants of different groups when exposed to different densities of vegetation ranging from no vegetation to extremely high density of vegetation?

Research Question 3:
Do higher densities of nature elicit greater stress recovery? Is the relationship linear, or does the effect lessen with greater and greater amounts of vegetation?

For participants who experience nature during the recovery period, is the stress recovery directly proportional to the amount of vegetation density or do any other groups show higher stress reduction?

Analysis of the data indicates that there is statistically significant difference in the stress levels of people recovering from a stressful event who are exposed to some kind of nature during their recovery period as compared to those who do not have any nature exposure,
even when the exposure lasts only for a brief amount of time. Results also show that there is difference in the stress reduction based on the amount of vegetation densities and amount of green in the urban parks. However, increasing the amount of vegetation does not lead to faster recover from acute stress and the relationship between vegetation densities and stress recovery is not linear. The results of this study show that moderately dense vegetation in an urban park is most beneficial for recovery from acute stress. While higher densities of vegetation do bring about effective changes in the stress level, higher densities are also perceived as overwhelming and arouse the feelings of fear and loss of control, which further increases stress. Analysis of the salivary alpha-amylase levels show a 177% (Cohen's $d=1.769$) reduction in stress among participants exposed to the medium density image post-nature-treatment. This change is statistically significant ($p<0.05$) as compared to the 70% (Cohen's $d=0.701$) reduction in the control group. The participants in the low density of vegetation group had a 77% (Cohen's $d=0.772$) reduction in stress while the stress reduced by 115% (Cohen's $d=1.157$) among participants in the high density of vegetation group. The main conclusion of this analysis is that relation between the amount of green exposure and recovery from stress is not linear, but can rather be described as an inverse U-Shaped quadratic curve in which moderate / medium vegetation density elicits greater stress reduction than either low or high levels of vegetation density. For individuals aged between 18-35 years, 3-minute expose to a nature image with moderate density of vegetation can evoke about 3 times the stress reduction than a 3-minute exposure to an image with no vegetation. Results
also make clear that as the percentage of vegetation cover increases from barren to greener scenes, there is a rapid increase in stress reduction until the density of vegetation reaches about 50% of the visible space. After that, increase in density of vegetation does not increase stress reduction, instead, higher densities predict higher stress or decrease in stress recovery.

6.1.3 Levels of Stress change are consistent across Gender and Race/ Ethnicity

Research Question 4A

Are there any gender differences in the relationship between exposure to different vegetation densities in nature and stress reduction when controlling for age and time?

This study found no statistically significant difference in stress reduction between the two gender groups. While some researchers have found gender differences in the salivary cortisol and skin conductance responses to the TSST and the nature treatment (Jiang et al., 2014), the participants of this study responded to the stress induction task and the nature treatment equally irrespective of gender. However, this does not mean that a gender difference to stress responses does not exist. It is known that men and women respond differently to stressful situations and it is possible that the impacts of nature images may also be differ between men and women (Jiang et al., 2014). Women tend to ruminate longer on the stress they experience, weakening the impact of nature and may require longer exposure to nature to gain a measurable stress reduction in the
the physiological responses (Simonson, Mezulis, & Davis, 2011; Jiang et al., 2014). Future research is required to explore the possible gender differences in stress recovery after nature exposure.

**Research Question 4B**

Are there any racial/ethnicity differences in the relationship between exposure to different vegetation densities in nature and stress reduction when controlling for age and time?

No significant difference was found between the different race/ethnicity groups either. Analysis of the salivary alpha-amylase levels from samples collected at the beginning of the quasi-experiment revealed that the African American participants in general had significantly higher levels of basal stress \( (p<0.05) \) as compared to Asian and Hispanic/Latino participants. The effect of stress induction task and the nature treatment was consistent across all ethnicity groups. However, this does not mean that a difference to stress responses does not exist across different ethnicities. The current study did not have homogenous sample to represent all the race/ethnicity groups equally. Clearly, more research is required to explore the possible race/ethnicity differences in stress recovery after nature exposure if we need to develop evidence-based guidelines for designers to address all groups of society.
6.1.4 Trier Social Stress Test (TSST) is a reliable tool for stress induction in laboratory setting.

Research Question 5:

Can Trier Social Stress Test (TSST) serve as an effective tool for moderate stress induction in laboratory settings in psychobiological and human-behavior studies?

For this study, it was essential that the participants' stress levels were elevated before they were exposed to the different treatment and control group images. Trier Social Stress Test (TSST) method was used to induce psychological stress in the participants before the nature treatment. The change in perceived and physiological stress before and after the procedure was measured used self-reported STAI scores and salivary alpha-amylase and salivary cortisol levels. Paired sample-t test was used to compare the participants’ stress level pre and post stressor. Results show that there was a significant change in the self-reported as well the physiological stress levels of the participants after the stress induction task. The mean salivary alpha-amylase levels increased more than 300% (Cohen’s $d=3.19$) and salivary cortisol levels increased more than 55% (Cohen’s $d=0.56$) from the baseline to immediately after the stress-inducing TSST procedure. This increase clearly indicates that the Trier Social Stress Test produced a stressful experience for the average participant. The TSST’s effect was also examined by gender and ethnicity; results demonstrate that TSST is an effective stressor for both genders as well as for all ethnic/racial groups.
6.1.5 Physiological measures are reliable for quantifying Stress in Design Studies

Research Question 6:

Does the stress measurement through self-reports complement the findings from biomarkers of stress measurement including salivary alpha-amylase and cortisol?

As a part of this study, self-reported measures of stress from STAI-S scores as well as physiological measures of stress from salivary alpha-amylase and cortisol were recorded. All three measures of stress served as the dependent variables for indicators of stress levels in this study. Usually design studies rely on self-reported measures of stress. But for this study, diurnal variations of salivary alpha-amylase and salivary cortisol were selected as biomarkers for stress measurement because they reflect the everyday physiological functioning of the HPA axis and are sensitive to a variety of responses to stress (Hsiao et al., 2010; Li et al., 2007; Ward et al., 2012). Correlation analysis allowed for exploration of relationships between salivary alpha-amylase, salivary cortisol and self-reported measures. Results indicate that the three measurements of stress used in this study are significantly correlated ($p< 0.01$). The correlation between salivary alpha-amylase levels and self-reported measure of stress ($r= 0.66$) is twice as strong as compared to correlation between salivary cortisol levels and self-reported measure of stress $r= 0.29$), suggesting that salivary alpha-amylase is a strong indicator of stress given the time frame within which the saliva samples were collected. The results also indicate that exposure to nature does aid recovery from acute stress and this stress response...
outcome can be measured both objectively by levels and/or patterns of cortisol and alpha-amylase secretion, or subjectively by self-reported measures of stress and general wellbeing. Using objective measures of stress responses that correlate with the subjective responses provides one explanatory mechanism behind the positive outcomes of nature exposure, increases the validity of the results and offers stronger empirical evidence while exploring the nature-health relationship.

6.2 Qualitative Findings

In addition to collecting quantitative data of stress levels, semi-structured interviews were conducted, which provided insights about the design of urban parks that can be associated with faster recovery from stress and which foster positive experiences of the natural environment. These qualitative findings add further understanding of specific design attributes of parks that have restorative effects on a stressed individual.

6.2.1 Moderately Dense and Complex Park is most effective for Stress Recovery

Research Question 8:

How are the visual design attributes of a park associated with stress recovery among the park users?

Content analysis of the structured interview responses suggest that the way the participants experienced the urban park setting that they were exposed to mainly
depended on the overall content of the setting as well as how the contents or elements were organized within the visual field. Participants who were able to visually comprehend what was going on around them were able to get a sense of security and thus felt more in control and intrigued. Those who could not completely understand their surroundings, became insecure and more distressed.

The treatment groups participants were exposed to one of the three urban park images differing in the amount of vegetation in each image and the control group saw an image of a parking deck. The control group image ranked the lowest in terms of preference and was labeled as ‘too structured’ with nothing much of interest to grab the attention of the participants or provide any form of restoration. The low vegetation density image was second in rank in the ‘low preference’ category owing to the large expanses of undifferentiated land covers with little to focus on. The participants were not enticed to explore the setting as it lacked any interesting points of focus and was labeled as ‘too boring’. Next up in ranking was the dense vegetation image. Participants expressed that high density vegetation image obstructed distant views and increased the feeling of fear and apprehension. Densely vegetated park was also perceived as a setting that lacked focus and lead to a concern about getting lost. The medium density image was the ‘most preferred’ setting. Participants described the medium density park image as an interesting setting with moderate levels of complexity that was easy to comprehend. The spatial configuration of this park was highly favored owing to the play of trees and
ground cover composition in harmony with the slopes and landform. The presence of water feature and sign of urban form through the presence of bridge and built structure in the distance also added to level of restoration and comfort in the medium dense vegetation park setting.

Figure 56: Balanced Composition of Park that allows for variety of experiences
The composition of the natural and designed elements within the urban park setting plays a critical role towards the experience of the park. Moderately complex compositions, defined by natural and human-made features create interesting environments that entice people into spending more time exploring. Urban parks embedded within the urban fabric with certain qualities and compositions allow for positive and stimulating experiences by increasing the variety and spontaneity of activities that can occur in the space. Urban parks that are moderate in scale provide more intimate experiences within smaller areas, allowing the uses to enjoy individual experiences such as taking a walk, reading a book, or simply relaxing at a comfortable spot. They also are large enough to accommodate large groups of people and encourage a number of social activities thus supporting social interactions.
CHAPTER 7: CONCLUSIONS

7.1 Main Conclusion of the study

This study addressed investigated the design attributes of urban parks that are most associated with recovery from acute stress. A novel methodological protocol was developed that allows use of physiological biomarkers as pragmatic measure of stress, as well as Immersive Virtual Environments (IVEs) to measure unambiguous design characteristics of natural environments and their impact on acute stress in people. This study particularly looked at the amount of vegetation within an urban park to explore if the recovery from acute stress was directly proportional to the amount of vegetation cover and if the two shared a linear relationship. The findings of this study suggest that brief exposure to moderate density of vegetation brings about a significant decrease in stress levels as compared to exposure to an environment with very few or no natural elements. As the percentage of vegetation cover increases from barren to greener scenes, there is a rapid increase in stress reduction until the density of vegetation reaches about 50% of the visible space. Higher densities of vegetation predict higher stress.

An urban park with moderate amount of vegetation, along with presence of water, visual connection to built form, subtle play of levels and landform with points of interest and potential for affordance, could create maximum recovery from daily urban stress. The findings expand the evidence base for well-being designers of the built environment and suggest that modifying urban green spaces by providing an enriched spatial
configuration, could increase the restorative quality of urban parks and offer extreme psychological benefits within a short amount of time. The methodological protocol established in this study can also be used in future studies that seek to test different environments for preference and restoration.

7.2 Strengths of the Study

The findings of this research make noteworthy contributions to several areas including literature on environmental-behavior research, methodological innovation and design implications based on empirical evidence.

7.2.1 Contribution to Environment-Behavior Research

The findings of this study are consistent with the theories of environment-behavior and environmental psychology research, and support the argument that exposure to and contact with nature is associated with and can influence well-being of people. This study also supports previous epidemiological research in using quantitative estimates of natural environments (Catharine Ward et al., 2012), but adds to the understanding of the underlying mechanisms by using an objective measure of acute stress. The findings of this study demonstrate that exposure to nature helps regulate the HPA axis as indicated by the salivary alpha-amylase and salivary cortisol, thus offering better opportunities for coping with stress. The findings support previous evidence that natural environments might be associated with stress reduction (Grahn & Stigsdotter, 2003; Hartig et al., 2003;
Maas, Verheij, et al., 2009; Ulrich et al., 1991; Ward et al., 2012). Research on exposure to green space and mental health showed the strongest positive effects on mood and self-esteem for the shortest duration (5 min) of presence in green space, irrespective of activity intensity (Barton and Pretty, 2010; Ward et al., 2012). The current study suggests that the amount of vegetation in natural environments also leads to differences in the coping mechanisms of individuals. The associations between high and moderate densities of vegetation and lower levels of stress found in this study direct attention towards a need for adequate levels of vegetation in urban parks and is an important aspect for consideration by landscape architects and urban planners when designing for green spaces within the urban infrastructure.

7.2.2 Methodological Innovation

One major strength of this study is the qualitative method, which allowed for a rich exploration of the mechanisms underlying the impact of experiencing virtual landscapes on mental well-being. This study offers new insights into links between vegetation densities in urban parks and health through an approach that measures salivary alpha-amylase and cortisol as an objective indicator of stress. These biomarkers of stress provide more reliable and pragmatic results and thus have wider acceptance and scientific relevance. Consequently, this approach offers perhaps greater external validity than previous studies that rely on self-reported measures of stress. This study also provides an innovative and systematic approach to exploring individual design elements
within urban parks and how they are associated with recovery from acute stress in individuals. The complexity of parks is broken down into finer elements that can be tested in isolation for their impact on physiological and psychological stress responses. This study employs a state-of-the-art technology of Immersive Virtual Environments using Oculus Rift VR-head gear.

Thus, this study successfully establishes a protocol that can be used for examining any kind of urban environment, built or natural, in association with its impact on human health and behavior.

7.3 Limitations of the Study

This study is an initial attempt to quantitatively describe the stress responses to contact with and exposure to nature using both self-reported and physiological measures. It also is a preliminary effort at evaluating specific design attributes of urban parks that support restorative experiences to stressed urban residents. This study has attempted to describe the impact of increasing densities of vegetation on stress reduction. Like any research study, this study has the following limitations related to the sampling, methodology, the outcome measures and generalizability of the findings.
7.3.1 Statistical Limitation

One of the main limitation of the study is the relatively small sample size (N=103). From the total sample, there were 26 participants in each of the treatment group, making the sample size within each category rather small. The size of the sample directly defines the precision or level of confidence that the sample estimates. Nonetheless, there was sufficient power in the sample to demonstrate significant findings in relation to the outcome measures. Also, this study used a convenient, non-probabilistic or purposeful population to attain the participants in the sample group. The participants for this study were limited to students of North Carolina State University, making it easy to recruit participants for the quasi-experimental study within the desired time frame and location. Future research may consider looking at a larger population sample, with differences in demographics and even different income groups. As literature suggests, the levels of stress is generally higher among the lower socio-economic status groups and the outcome of this study may be different when looking at vulnerable and disadvantaged populations. Also, the number of participants were not consistent across gender and ethnicity groups. This study did not find any significant differences in the stress responses between male and female participants. However, literature suggests that such differences are likely. Therefore, further research is required using a more homogenous sample to test for any gender or ethnicity group differences in stress responses to nature exposure.
7.3.2 Methodological Instrument Limitation

Immersive Virtual Reality Environments (IVEs) were used in this study to provide virtual exposure to nature to the participants after the stress-inducting task. 3D Immersive Virtual Reality Environments (IVEs) serve as a great tool as a surrogate for real landscapes that allow the researcher to control the conditions that are being examined. But it is only likely that the richness of the real environment is lost when experiencing virtual landscapes. When in the real settings, an individual interacts with the surrounding environment with all the senses. Literature suggests that in addition to visual cues, sound, smell and touch of natural elements also provide restorative benefits. In the real environments, many other factors such as presence of people, animals, noise, temperature, sunlight, humidity, etc. can all impact the outcomes being measured. Another limitation related to using virtual reality environments is that the participants’ capabilities of perceiving and immersing into a given virtual setting may vary and thus may generate different stress outcomes. Experiencing Immersive Virtual Environments (IVEs) for the first time can also cause arousal and excitement among the participants, and thus the physiological measurement stress outcome may not be a true representation of the stress level of the participant. Thus future research examining differences in participants’ stress responses, who are exposed to real landscapes versus those who experience the same scene in immersive virtual environment, is required.
### 7.3.3 Outcome Measurement Limitation

This study employed salivary alpha-amylase and salivary cortisol levels as biomarkers for stress measurements in addition to self-reported STAI scores. To keep each participant’s time of engagement in the study short, saliva samples were collected at 15 minutes after the stress induction and 15 minutes after the nature treatment. Literature suggests that the mean effect size for cortisol responses to stress is the greatest 21-30 minutes after the onset of the stressor (Dickerson & Kemeny, 2004), while alpha-amylase response peaks at 0-15 minutes after the stressor (Nater et al., 2005). There are possible biological differences in the amount and flow of saliva and it is difficult to measure the absolute peak in the alpha-amylase or cortisol levels for each participant. For future studies, employing longer post-treatment sampling period along with increase in number of saliva samples collected following the treatment is recommended. This monitoring at close intervals would give a better understanding of the effects of nature treatment on stress responses.

### 7.3.4 The Challenge of Defining Less Measurable Attributes

This study attempts to quantify the amount of vegetation that is ideal for recovery from stress within a brief amount of time as well as evaluate the other design characteristics of urban park that provide restorative benefits. Evaluation of structural composition of a natural environment is less manageable and measurable as that requires in depth analysis, expertise and advanced computer algorithms. The field of visual aesthetics has
made significant headway in its methodology for evaluating human preference in terms of color and spatial structure comprising of lines, symmetry, spatial proportion, balance, contrast etc. (Hunter & Askarinejad, 2015). However, most often, these analyses can only be made for 2D images limiting the true understanding of depth and composition in the third dimension. Multiples studies evaluating one characteristic at a time are required to generate a holistic understanding of the design elements of urban parks that bring about maximum stress reduction.

7.3.5 Lack of External Validity

One main concern of this study is also its external validity; whether the findings of this study have the potential for applicability to the larger world or if there are defining contextual constraints within which the results are valid (Groat & Wang, 2001). Experimental approach that this study has employed is generally considered to represent the highest standard of research (Groat & Wang, 2001). However, experimental design is also widely criticized for over simplifying and isolating complex phenomena that occur in real-life settings. The participants of this study were exposed to a single image of one park that was digitally modified to show different densities of vegetation. Findings of this study are based on one treatment image that the participants experienced. Thus, generalization is inherently in question. Further research is necessary to test the effects of nature using other park images or real settings. This study, however, proposes a systematic way of measuring stress responses to brief exposure to nature. Irrespective of
the type of environment or specific design element in the environment being evaluated, the approach to measuring stress responses would bear conceptual similarities. The methodological protocol developed in this study can be modified for use for different research settings. The findings of this study may have limited generalizability, but the methodological approach can guide similar studies in various different contexts.

7.4 Implications for Future Policy, Design and Research

The pressures of modern living in cities are precursors to increasing number of problems that we face today including chronic illness, social stress, and larger social disparity. City living also involves an extraordinary disengagement of humans from the natural environment that is likely to be detrimental to health and wellbeing. These prevailing issues in the urban contexts have led to growing need for communal spaces within the urban environment.

This study provides empirical evidence to show that urban parks, that were once considered as the simple aesthetic addition to an urban environment in terms of look and feel, can also produce measurable effects on our mental health. Analysis and discussions mentioned above indicate that moderately vegetated parks that have visual connectively to water and urban form have a strong potential to reduce people’s negative mood, optimize people’s visual preference and eventually reduce stress. At present, efforts are being made to dramatically transform all urban landscapes through
careful planning. Urban parks are now one of the most important elements of any city’s planning as they not only protect the essential systems of life and biodiversity, but are also a fundamental setting for health promotion and creation of well-being among urban residents.

This study identifies the urban park design characteristics associated with recovery from acute stress in urban residents. This knowledge can directly be translated to park design practice in order to support restrictiveness and enhance mental well-being in the urban context. This study statistically illustrates what amount of vegetation in urban parks is most effective in aiding recovery from acute stress among urban residents and what design elements within urban parks can provide avenue for healing, therapy and restoration in today’s fast-paced, increasingly plugged in society.

Concluding the findings of this study, it can be said that urban parks, with moderate amount of vegetation, that have a play of slopes and levels, have visual connection with some form of water and have some lateral visibility to urban built environment can help individuals recover from daily stress within a short amount of time.

7.5 Recommendations for Future Studies

The quintessential goal of this study was to evaluate the design characteristics of urban parks that are ideal for recovery from stress within a brief amount of time and that
provide highest restorative benefits. Systematic understanding and measurement of the design attributes of urban parks, though essential, is extremely challenging. Natural elements are difficult to abstract and thus difficult to quantify and measure. This research raised many questions in need of further investigation.

Previously established categories for landscape elements, namely vegetation, water, landform, structure and sky (Schauman, 1979) are used and one element, i.e., the vegetation, is examined. This study makes an effort to develop a protocol to measure the urban park design in terms of vegetation densities and how different densities influence levels of stress in people. Further work needs to be done to establish whether other attributes of vegetation, such as form, type, color, etc. cause the same effects on stress reduction. Further experimental investigations are needed to estimate the effect of other landscape elements such as water and landform for a holistic understanding of urban park design in association with stress recovery. It is thus recommended that further research be undertaken using the methodological protocol outlined in this study employing different park settings to improve reliability and generalizability.

The current study used a convenient sample comprising of students from North Carolina State University. Further research using a larger sample with differences in age groups, ethnicities, socio-economic statuses and even geographic locations is recommended.
Findings can then inform designers of the susceptibility of specific populations and appropriate design interventions can be made to help maintain well-being.

This study used Immersive Virtual Reality Environments as a way to provide nature exposure during the recovery period. However, virtual environments compromise on the richness and sensory arousal of the real environments. Thus future research examining differences in participants’ stress responses, who are exposed to real landscapes versus those who experience the same scene in immersive virtual environment, is recommended. Comparing and contrasting findings of this study with those of real environment studies will provide further insights of the mechanisms of how exposure to nature improves levels of stress and thus mental well-being and provide more solid groundwork for future park-design studies.

This study was also limited in time and used saliva samples taken 15 minutes after the stressor and 15 minutes after the nature treatment. For future studies, employing longer post-stressor and post-treatment sampling period along with increased number of saliva samples collected following the treatment is recommended. This monitoring at close intervals would help illustrate the effects of nature on stress levels in a more comprehensive way.
Undoubtedly, much more work is required is in this area if we are to develop evidence-based guidelines for designers (Brown & Corry, 2011; Jiang et al., 2014). This study is just a preliminary effort at evaluating specific design attributes of urban parks that support restorative experiences to stressed urban residents.

7.6 Subjective Claims

This study evaluates of the amount of green exposure through urban parks in association with stress reduction among its users. To contextualize the researcher’s interest in the topic, it is important to outline the process of arriving at it.

The researcher began reading about the health benefits associated with the built environment and how this link is more prominent in distressed and disadvantaged communities, which then opened to her the world of current mental health issues and initiated her interest in designing for mental well-being. Progressively, during early stages of research, the relationship between the designed natural environment and its impact especially on mental health became the core of her study. She is not trained as a landscape architect or psychologist; this study is therefore not an attempt to describe the ‘ideal’ environment for ‘ideal’ mental health, but rather to describe and analyze the effects of certain design features on the stress levels of people. This is not a judgmental study in landscape design terms, that is, she is not saying that environment ‘x’ or park ‘x’ is better than environment ‘y’ or park ‘y’. Rather, this is a study that seeks to account
for how people feel about and respond physiologically to certain park environments that they spend time in. It is her hope that landscape designers and park planners would look at the results of this study to make informed design decisions when planning for urban parks that can promote overall well-being of people, in terms of both physical and mental health.

The task she has undertaken, however, remains an enormous and a challenging one and for several reasons. To begin with, though there has been a lot of research on restorative environments, there is limited literature that provides detailed information about the specific attributes or elements of the physical environment or design of parks that aids this restoration. In addition to that, and probably as a consequence, the methodologies available to her are not well established, especially in the design discipline. Indeed, the researcher had to develop them in order to answer the research questions of this study. And finally, since there is a lack of design solutions for the ever growing issue of mental ill-health, it is important to draw these together into a single analysis framework.
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APPENDICES

Appendix A: Photographic Survey Questions

The purpose of this exercise is to understand how experts in landscape architecture and park design would classify different urban parks based on the densities of vegetation. The results from this exercise would be helpful when digitally modifying an urban park setting with varying vegetation densities. The second task will be helpful in selecting one park setting that can be used for the virtual reality experiment.

Task 1:
Please categorize the given images into 3 groups based on the density of vegetation; namely low, medium and dense. You may discard any images that you think do not fit the classification criteria.

Task 2:
A. Imagine you are feeling stressed or have had a hard day. Now you have a choice to go outdoors and spend some time in an Urban park. From the given images, please select 5 images of locations that you may consider to be most beneficial in your stress reduction.

B. Rank the selected five images in order of preference of locations that you think will help you feel relaxed or less stressed.
Appendix B: GigaPan Epic Pro User Manual

Capturing Images for 360° Panoramas
with the DSLR Camera and the GigaPan EPIC Pro

Checklist of equipment to pack
☐ Tripod and carrying case.
☐ GigaPan EPIC Pro, connecting cable, and backpack.
  Make sure the battery in the GigaPan and the extra battery are charged
☐ Canon DSLR and backpack.
  Pack an extra SD card and make sure the battery in the camera and the backup battery are full.

Setting up the Hardware:
1. Set up the tripod.
2. Unpack the GigaPan.
3. Slide the GigaPan into the tripod’s mount and wait for the click to ensure that it’s all the way in.
4. Tighten the screw on the right side of the tripod to lock the GigaPan in.
5. Press and hold the power button on the GigaPan until it powers on.
6. Press the down button until you can highlight the MOVE CAMERA option, press OK.
7. Hold the down button until the camera rail is level or angled up slightly.
8. Rotate the locking pin to the unlocked position (parallel with the camera rail).
9. Place the camera in the mount and rotate the locking pin to the locked position.
10. Make sure the small silver pin is also locked.
11. Connect the cable between the camera and the GigaPan.

Camera Setup:
1. Make sure the GigaPan is on.
2. Scroll down and highlight CAMERA SETUP, select OK.
3. Select SET.
4. Align the horizon with the top of the camera screen (using the viewfinder) at the prompt.
5. Align the horizon with the bottom of the camera screen (again with the viewfinder) at the next prompt.
6. The camera FOV should be around 40°.
7. Power on the camera.
8. Set the click-wheel setting to the ‘P’ setting. This is one click above the ‘full auto’ (green box) setting.
9. Ensure that the stabilizer is ON. This setting is on the left side of the lens.
10. Ensure that the auto-focus is ON. This setting is also on the left side of the lens, just above the stabilizer switch.

11. Ensure that the zoom is locked in all the way. The lock is D-shaped and is located on the right side of the lens.

12. To set the correct exposure settings, press the menu button on the back of the camera and scroll to the second camera settings box (red box). Scroll down to the ‘White balance’ setting and select either ‘Daylight,’ ‘Shade,’ or ‘Cloudy’ according to the current conditions. Select ‘Set.’ Press the menu button again to exit out of the menu screen.

**Taking Photos to Create a 360° Panorama:**

1. Take a picture of your hand or something noticeable to indicate the beginning of a new panorama.
2. On the GigaPan display, scroll down and highlight NEW 360 PANORAMA.
3. When prompted to SET CAMERA’S zoom, select OK.
4. When prompted to move the camera to the top of the image, use the GigaPan controls to move the camera to the top of the panorama. This is about 55 degrees on the wheels on either side of the GigaPan’s arms.
5. Next, Use the GigaPan controls to move the camera to the bottom of the panorama. This is about -55 degrees.
6. When prompted to SHOW PANORAMA, select NO.
7. When prompted to START PANORAMA, select OK.
8. It should take about 40 to 54 photos.
9. Ensure that the camera takes EVERY photo as the GigaPan pans it around. If it skips one, then one of the camera’s settings are off and you’ll need to start over.
10. Finally, once the camera has taken all of the photos, take another picture of your hand or something noticeable to indicate the end of the panorama.
Appendix C:   IRB Approved- Call for Participation / Advertisement:

Appendix C.1: Email communication:

Invitation to participate in a study on Urban Park Design
by Ph.D. Candidate at College of Design, NCSU

Dear NCSU Students and Faculty,

I’m writing this email/post to invite you to participate in our study on Urban Park Design and its health benefits.

The purpose of this study is to broaden the understanding of design characteristics of urban parks or green spaces in people’s everyday urban life and its association with mental health. The study seeks to understand the amount of green exposure that is most beneficial for stress reduction and also gain information as to whether certain park features are more closely associated with mental health and positive experience of the park. Results may enable designers to create urban parks that are not only supportive of physical activity but also can promote mental well-being.

The study will take approximately 45 minutes to an hour. Each participant will have a chance to win one of the five $25 gift cards for NC State Bookstore that will be given as prizes. Winners will be selected through a drawing at the end of the study.

The study will be held at the Leazer and/or Brooks Hall at the College of Design, NC State Campus

If you wish to participate in the study, please contact me at schedule a date and time.

Thank you for your interest.

Kind Regards,
Sonika Rawal

sorawal@ncsu.edu | 919-325-6061
College of Design, North Carolina State University

Please Note:
You are being asked to voluntarily take part in the study. You are not required to participate regardless of whether or not you are a student in the design curriculum, or know the researchers involved. You should only participate if you want to contribute to this investigation/research. All the information collected from you during the study will be kept confidential and will not affect your student status at NC State in any way. We appreciate your support and thank you for considering participating
Join a research study investigating the amount of green or nature exposure that is most beneficial for stress recovery in urban park users.

Qualified participants will:
• Get to experience Immersive Virtual Reality (IVR) environments using Oculus Rift
• Get a chance to win on one of the five $25 gift cards for NC State Bookstore

Inclusion Criteria:
• Age 18-35 years old
• No history of cardiovascular diseases, depression, or post-traumatic stress disorder
• Can spare one hour of your time

For more information or to participate in the study, please contact:

Sonika Rawal
sorawal@ncsu.edu
919-325-6061
Appendix C.3: Advertisement on Facebook and other Social Media:

Oculus Rift on Campus!!

Now if that caught your attention, you may be interested in participating in the research study mentioned below. This is an exciting way to start the new semester! At the College of Design, I am conducting a research study that seeks to investigate the amount of green or nature exposure beneficial for health of urban park users. I invite you to participate in this study titled “Rx Vitamin G”. The results may enable designers to create urban parks that are not only supportive of physical activity but also promote mental well-being.

If you are between ages 18-35 with no history of cardiovascular diseases, depression, or post-traumatic stress disorder, we invite you to participate in this study. Qualified participants will get to experience Immersive Virtual Reality (IVR) environments using Oculus Rift. You will also have a chance to win one of the five $25 gift cards for NC State Bookstore that will be given as prizes. Winners will be selected through a drawing at the end of the study.

The study will require about an hour of your time and will be held at the Leazer and/or Brooks Hall at the College of Design, NC State Campus.

If you wish to participate in the study, please contact me to schedule a date and time. Thank you for your interest.

Kind Regards,
Sonika Rawal
sorawal@ncsu.edu | 919-325-6061
College of Design, North Carolina State University

Please Note:
You are being asked to voluntarily take part in the study. You are not required to participate regardless of whether or not you are a student in the design curriculum, or know the researchers involved. You should only participate if you want to contribute to this investigation/research. All the information collected from you during the study will be kept confidential and will not affect your student status at NC State in any way. We appreciate your support and thank you for considering participating.
Appendix D: Randomized Distribution of Participants in 4 Groups

Group A = Low  
Group B = Moderate  
Group C = High  
Group D = Control

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How it works: The random number generator is seeded with the time of day, so it works differently each time you use it. Each subject is first assigned to a group non-randomly. Then the assignment of each subject is swapped with the group assignment of a randomly chosen subject. This should suffice, but the entire process is repeated twice to make sure it is really random.
Appendix E:  IRB Approved Informed Consent Form

NORTH CAROLINA STATE UNIVERSITY

INFORMED CONSENT FORM for RESEARCH

Before agreeing to participate in this research study, it is important that you to read and understand the following purpose, benefits and risks of the study and how it will be conducted.

Title of Study: Rx Vitamin G: Role of Urban Parks in Stress Reduction
An evaluation of physical park settings in association with stress reduction among its users.

Principal Investigator: Sonika Rawal
PhD Candidate at College of Design
North Carolina State University
Email: sorawal@ncsu.edu
Tel: 919-325-6061

Faculty Supervisor: Dr. Celen Pasalar
Assistant Dean for Research and Extension
Assistant Professor of Landscape Architecture/Affiliate PhD Faculty
College of Design, North Carolina State University

What are some general things you should know about research studies?

You are invited to participate in a research study being conducted by a PhD candidate at the College of Design of North Carolina State University. You were chosen to participate in this study because you are aged between 18 and 35 years and you volunteered to participate. Your participation in this study is completely voluntary. You should read the information below and ask questions about anything that you do not understand before deciding whether to participate. You may also decide to discuss participation with your family or friends. The decision to join is up to you and you also have the right to stop participating at any time without penalty.

The purpose of this study is to gain a better understanding of how urban parks effect well-being of people. Participating in a research study is not the same as getting regular medical care for physical and mental health. The purpose of regular medical care is to improve your health. The purpose of a research study is to gather information.

You are not guaranteed any personal benefits from being in a study. Research studies also may pose risks to those that participate. In this consent form you will find specific details about the research in which you are being asked to participate. If you do not understand something in this form it is your right to ask the researcher for clarification or more information. A copy of this consent form will be provided to you. If at any time you have questions about your participation, do not hesitate to contact the researcher(s) named above.
**What is the purpose of this study?**

You are being asked to participate in this study because we are trying to understand how urban parks are associated with well-being of people. This study is designed to enable us to collect information about how people react in different park settings and whether certain park features are more closely associated with mental health and positive experience of the park.

**What will happen if you take part in the study?**

If you agree to participate in this study, you will be asked to provide some demographic information, perform a few tasks as described below and take part in a brief interview. It is anticipated that the study will require 40-50 minutes of your time.

After you have provided your demographic and health information, a saliva sample will be collected from you. You will be asked to chew on an oral swab for about a minute and then that swab will be stored and frozen in a small vial. You will then be asked to take a simple test. The results of this test are not a part of your school grade and the professors will not have access to these results. After the test, a second saliva sample will be collected using the same method.

After this, you will randomly be assigned to one of the four study groups and you will be asked to wear a head mounted device (HMD) that will be used to display a virtual image of an urban setting to you. You will be asked to spend 3 minutes wearing the HMD and experiencing the virtual environment.

On completion, a third saliva sample will be collected.

You will then be asked to fill out a questionnaire about the virtual environment you experienced followed by an interview which will be recorded for transcription.

**Potential Risks and Discomforts:**

The risks involved with the study may include minor discomfort while chewing on the oral swab and discomfort while using the head mounted device.

You will be allowed to spit in the vial if chewing on the swab is uncomfortable. You will also be allowed to play around, adjust and wear the head mounted device in the most comfortable manner.

**Potential Benefits to subject and/or the society:**

The study is not designed to benefit you directly. However, the society may benefit indirectly from your participation as the results of this study may help designers design and create urban parks that help the users to deal with urban stress thereby affecting their overall well-being. The results of the study will also add to the body of knowledge dealing with health benefits of nature.
Confidentiality:

The information in the study records will be kept confidential to the full extent allowed by law. You will be assigned a unique ID number. Samples and other data collected from you will be labeled with this ID number. Although your name will be collected on this consent form, it will be kept in a separate place from the data. The information connecting you with the ID number will be available only to the principal investigator. As for the interviews, it will be taped only with your permission so that it can be transcripted accurately. The tape will be destroyed as soon as the transcript is completed.

The results of the study will be in aggregate terms and no individual responses will be described. No names or IDs will be used in the results of the study. No reference will be made in oral or written reports which could link you to the study.

Compensation:

For participating in the study, you will have the option of being entered in the drawings for one of five $25 gift cards for NC State Bookstore. If you withdraw from the study prior to its completion, you will not be entered in the drawings.

What if you are a NCSU student?

Participation in this study is not a course requirement and your participation or lack thereof, will not affect your class standing or grades at NC State University.

What if you are a NCSU employee?

Participation in this study is not a requirement of your employment at NCSU, and your participation or lack thereof, will not affect your job.

What if you have questions about this study?

If you have questions at any time about the study or the procedures, you may contact the researcher Sonika Rawal at sorawal@ncsu.edu or by phone at (919)325-6061.

What if you have questions about your rights as a research participant?

If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact Deb Paxton, Regulatory Compliance Administrator at dapaxton@ncsu.edu or by phone at (919) 515-4514.
Appendix F: IRB Approved - Demographics and Health Questionnaire

Name: ________________________________

Date of Birth: ___________________________ Gender: ( ) Male ( ) Female
(mm/dd/yyyy)

Age: ( ) 17 or below ( ) 18-22 ( ) 23-29 ( ) 30-35

Telephone: ____________________________ Email: ____________________________

Address: ______________________________

City: __________________ State: __________________ ZipCode: __________

Civil Status: ( ) Single ( ) Married ( ) Separated ( ) Widow ( ) Choose not to answer

Current status at NCSU: ( ) Full-time Student ( ) Part-time Student ( ) Employee

College/ Department: ________________________________

Major/ Program: __________________________ Degree level: _________________

Race/ Ethnicity: ( ) White/ Non-Hispanic
( ) African American/ Black
( ) American Indian/ Alaskan Native
( ) Asian
( ) Hispanic/Latino
( ) Other
( ) Choose not to answer

Place of birth: __________________________
(City) (State) (Country)

Which of the following best describes the places you lived in as a child (age newborn to ten)?
( ) Town (population 1 - 50,000)
( ) Small city (population 50,000 - 300,000)
( ) Large city (population over 300,000)
( ) Don't know

Which of the following best describes the kind of communities you lived in as a child (age newborn to ten)?
( ) Lived within the city (town) limits / urban setting
( ) Lived in a suburban setting (within 15 miles of a small or large city)
( ) Lived in a rural setting
( ) Don't know
Which of the following best describes the topography/landscape of the places where you lived in as a child (age newborn to ten)?

( ) Mountainous and hilly
( ) Coastal area or proximity to the beach/ocean
( ) Proximity to water bodies like lakes, ponds, rivers
( ) Landform such as flatlands, fields, farmlands.
( ) Mostly urban and cityscape

Please list the places where you have lived for more than 6 months during the last three years and state the amount of time you lived in each of these places.

________________________________________________________________________________________

________________________________________________________________________________________

Current health condition: ( ) Excellent ( ) Good ( ) Fair ( ) Poor

If you are a female, are you currently pregnant or nursing? ( ) N/A ( ) Yes ( ) No

Do you currently have any physical disability? ( ) Yes ( ) No

If “yes”, please provide details below:

________________________________________________________________________________________

Have you ever been treated for a mental, emotional, psychological, or personality disorder/condition/problem? ( ) Yes ( ) No

If “yes”, please provide details below:

________________________________________________________________________________________

Have you been diagnosed, treated, medicated, and/or monitored for any of the conditions listed below within the last 3 years? (Choose all that apply)

( ) None
( ) High Blood Pressure
( ) High Blood Cholesterol
( ) Diabetes
( ) Cardiovascular or lung disease
( ) Thyroid Disorder
( ) Other Please specify: ____________________________

How do you wish to be contacted in case you get selected for the gift card? (Choose all that apply):

( ) Email
( ) Text
( ) Phone Call
# Appendix G: IRB Approved - Perceived Stress Scale Questionnaire

The questions in this scale ask you about your feelings and thoughts during the last month. In each case, please indicate with a check *how often* you felt or thought a certain way.

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>In the last month, how often have you been upset because of something that happened unexpectedly?</td>
<td>Never</td>
<td>Almost never</td>
<td>Sometimes</td>
<td>Fairly often</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>2</td>
<td>In the last month, how often have you felt that you were unable to control the important things in your life?</td>
<td>Never</td>
<td>Almost never</td>
<td>Sometimes</td>
<td>Fairly often</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>3</td>
<td>In the last month, how often have you felt nervous and “stressed”?</td>
<td>Never</td>
<td>Almost never</td>
<td>Sometimes</td>
<td>Fairly often</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>4</td>
<td>In the last month, how often have you felt confident about your ability to handle your personal problems?</td>
<td>Never</td>
<td>Almost never</td>
<td>Sometimes</td>
<td>Fairly often</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>5</td>
<td>In the last month, how often have you felt that things were going your way?</td>
<td>Never</td>
<td>Almost never</td>
<td>Sometimes</td>
<td>Fairly often</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>6</td>
<td>In the last month, how often have you found that you could not cope with all the things that you had to do?</td>
<td>Never</td>
<td>Almost never</td>
<td>Sometimes</td>
<td>Fairly often</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>7</td>
<td>In the last month, how often have you been able to control irritations in your life?</td>
<td>Never</td>
<td>Almost never</td>
<td>Sometimes</td>
<td>Fairly often</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>8</td>
<td>In the last month, how often have you felt that you were on top of things?</td>
<td>Never</td>
<td>Almost never</td>
<td>Sometimes</td>
<td>Fairly often</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>9</td>
<td>In the last month how often have you been angered because of things that were outside of your control?</td>
<td>Never</td>
<td>Almost never</td>
<td>Sometimes</td>
<td>Fairly often</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>10</td>
<td>In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?</td>
<td>Never</td>
<td>Almost never</td>
<td>Sometimes</td>
<td>Fairly often</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
</tbody>
</table>
Appendix H: IRB Approved - Script for Trier Social Stress Test (TSST)

Researcher (R1):

“This is the speech preparation portion of the task. 
________________________ (Confederate’s Name) is a communication and public speaking specialist. He/ she is here to assess how outgoing, expressive, and comfortable you are in situations in which you must project yourself as an expert. This is a type of personality test for a trait called extraversion.

Imagine a hypothetical situation in which you are applying for your ‘ideal job’. After submitting your application, you have been invited for an interview. This job pays a very large salary. You are competing against a lot of other candidates, and the final selection will be made based on your ability to convince the interviewers of how your experiences, abilities, and education make you a better candidate that the others. You will try to convince this panel of interviewers that you are the best fit for the position.

You are to mentally prepare a five-minute speech describing why you should be hired for this position. Remember, this examiner is specially trained in public speaking to monitor and rate your speech for its believability and convincingness, and will compare your performance to that of the others who perform this task. Also, your speech will be videotaped during the task so that the examiner can go over the videotape carefully and rate the contents of your speech as well as your nonverbal behavior.

You have five minutes to prepare and your time begins now.”

Confederate (C1)/ Panel - During TSST:

“This is the speech portion of the task. You will now tell us why you would be a good candidate for your ideal job. You should speak for the entire the five-minute time period. Your time begins now.”

If the participant stops talking during the speech, allow him/her to be silent for 20 seconds. If he/she does not resume speaking, prompt him/her to continue speaking by instructing them:

“You still have time remaining. Please continue.”

If the participant asks questions as to why he/she is being questioned or interviewed, respond as:

“I am not allowed to tell you that. Someone will give you that information later.”
Confederate (C1)/ Panel - After 5 minutes’ time period:

“Now is the final math portion of this task. We would like you to subtract number 13 from 1022, and keep subtracting 13 from the remainder until we tell you to stop. You should do the subtraction as fast and as accurately as possible.”

You will verbally report your answers aloud, and be asked to start over from 1022, if a mistake is made. Your time begins now.”

If the participant makes a mistake, prompt with:

“That is incorrect, please start over from 1022.”

The answers are as follows (for panel’s reference):

<table>
<thead>
<tr>
<th>1022</th>
<th>1009</th>
<th>996</th>
<th>983</th>
<th>970</th>
<th>957</th>
</tr>
</thead>
<tbody>
<tr>
<td>944</td>
<td>931</td>
<td>918</td>
<td>905</td>
<td>892</td>
<td>879</td>
</tr>
<tr>
<td>866</td>
<td>853</td>
<td>840</td>
<td>827</td>
<td>814</td>
<td>801</td>
</tr>
<tr>
<td>788</td>
<td>775</td>
<td>762</td>
<td>749</td>
<td>736</td>
<td>723</td>
</tr>
<tr>
<td>710</td>
<td>697</td>
<td>684</td>
<td>671</td>
<td>658</td>
<td>645</td>
</tr>
<tr>
<td>632</td>
<td>619</td>
<td>606</td>
<td>593</td>
<td>580</td>
<td>567</td>
</tr>
<tr>
<td>554</td>
<td>541</td>
<td>528</td>
<td>515</td>
<td>502</td>
<td>489</td>
</tr>
<tr>
<td>476</td>
<td>463</td>
<td>450</td>
<td>437</td>
<td>424</td>
<td>411</td>
</tr>
<tr>
<td>398</td>
<td>385</td>
<td>372</td>
<td>359</td>
<td>346</td>
<td>333</td>
</tr>
<tr>
<td>320</td>
<td>307</td>
<td>294</td>
<td>281</td>
<td>268</td>
<td>255</td>
</tr>
<tr>
<td>242</td>
<td>229</td>
<td>216</td>
<td>203</td>
<td>190</td>
<td>177</td>
</tr>
<tr>
<td>164</td>
<td>151</td>
<td>138</td>
<td>125</td>
<td>112</td>
<td>99</td>
</tr>
<tr>
<td>86</td>
<td>73</td>
<td>60</td>
<td>47</td>
<td>34</td>
<td>21</td>
</tr>
</tbody>
</table>

If the participant asks questions as to how he/she did, respond as:

“I am not allowed to tell you that. Someone will give you that information later.”
Appendix I: IRB Approved - Post-TSST Self-Evaluation Questionnaire:

Below is a list of experiences people sometimes have during and after a stressful experience. Please read the following statements carefully and select the answer to the right to indicate how you feel *RIGHT NOW*, as in, *at this very moment*. There are no right or wrong answers. Do not spend too much time on any one statement but select the answer that seems to describe your present feels best.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Very Less</th>
<th>Less</th>
<th>Same</th>
<th>More</th>
<th>Much More</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>I feel different from the way I was feeling when I came in</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>2.</td>
<td>I am stressed</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>3.</td>
<td>I am satisfied</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>4.</td>
<td>I feel calm</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>5.</td>
<td>I feel nervous</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>6.</td>
<td>I feel confident</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>7.</td>
<td>I feel restless</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>8.</td>
<td>I feel rested</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>9.</td>
<td>I have difficulty concentrating</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>10.</td>
<td>I feel at ease</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>11.</td>
<td>I am upset</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>12.</td>
<td>I am relaxed</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>13.</td>
<td>I feel anxious</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>14.</td>
<td>I feel blanked out</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>15.</td>
<td>I feel worried</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>16.</td>
<td>I have disturbing thoughts</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>17.</td>
<td>I am tense</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>18.</td>
<td>I feel steady</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>19.</td>
<td>I am presently worrying about possible misfortunes</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>20.</td>
<td>I feel pleasant</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
</tbody>
</table>
Appendix J: IRB Approved - Post-Treatment Self-Evaluation Questionnaire

Below is a list of experiences people sometimes have during and after being in contact with nature. Please read the following statements carefully and select the answer to the right to indicate how you feel *RIGHT NOW*, as in, *at this very moment*. There are no right or wrong answers. Do not spend too much time on any one statement but select the answer that seems to describe your present feels best.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Very Less</th>
<th>Less</th>
<th>Same</th>
<th>More</th>
<th>Much More</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>I feel different from the way I was feeling when I came in</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>I am stressed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>I am satisfied</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>I feel calm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>I feel nervous</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>I feel confident</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>I feel restless</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>I feel rested</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>I have difficulty concentrating</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>I feel at ease</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>I am upset</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>I am relaxed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>I feel anxious</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>I feel blanked out</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td>I feel worried</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td>I have disturbing thoughts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.</td>
<td>I am tense</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td>I feel steady</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19.</td>
<td>I am presently worrying about possible misfortunes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20.</td>
<td>I feel pleasant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21.</td>
<td>The image changed my mood negatively</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22.</td>
<td>The image changed my mood positively</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23.</td>
<td>The image made me feel stressed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24.</td>
<td>The image made me feel relaxed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25.</td>
<td>I liked the image I just experienced</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The setting you just experienced comprised of a number of different elements of nature. What do you think contributed **most** to your change of mood?

- ( ) Entire Park
- ( ) Vegetation/ greenery
- ( ) Water element
- ( ) Slope and landform
- ( ) Skyline

People have different ways of dealing with daily stressors and prefer to be in different environments when they feel stressed.

<table>
<thead>
<tr>
<th></th>
<th>not at all/ never</th>
<th>mildly/ a few times</th>
<th>sometimes</th>
<th>moderately/ often</th>
<th>much/ always</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Would you to spend time in this exact environment setting when you are feeling stressed?</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>2. Would you to spend time in this exact environment setting when you are happy or relaxed?</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>3. Would you recommend a friend or family member to visit this exact setting when they are feeling stressed or depressed?</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
</tbody>
</table>
Appendix K: IRB Approved - Park Use Questionnaire

This survey will focus on the pattern of your use of green spaces. In this survey, green spaces shall refer only to neighborhood and community parks that are open to public.

<table>
<thead>
<tr>
<th>Neighborhood Parks:</th>
<th>These are smaller parks within the immediate residential community or private estates. Neighborhood parks generally range from 2 to 5 acres serving a population of approximately 3,000 to 6,000. Their purpose is to provide daily unprogrammed recreational needs of residential areas within the neighborhood unit.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community Parks:</td>
<td>These are large recreation facilities serving a population of approximately 18,000 to 36,000 within a 1-2-mile radius. Their purpose is to provide both preservation of natural features within the urban environment and programmed recreational needs on a community wide basis.</td>
</tr>
</tbody>
</table>

1) How often do you visit the green spaces that are within walking distance to your house? (i.e., you get there by foot, in 10 min or less.)
   ( ) Everyday
   ( ) Weekly
   ( ) Once in 6 months
   ( ) 1-3 times a week
   ( ) Monthly
   ( ) Once in 3 months
   ( ) 1-3 times a month
   ( ) Yearly
   ( ) Never

2) How frequently do you visit green spaces that are far from your house? (i.e., you cannot get there within 10 min by foot.)
   ( ) Everyday
   ( ) Weekly
   ( ) Once in 6 months
   ( ) 1-3 times a week
   ( ) Monthly
   ( ) Once in 3 months
   ( ) 1-3 times a month
   ( ) Yearly
   ( ) Never

3) How long do you normally spend in green spaces each time you visit them?
   ( ) Less than 30 min
   ( ) 30 min to 1 hour
   ( ) 2-3 hours
   ( ) More than 3 hours
   ( ) Other

4) How do you normally travel to green spaces when you visit them? (Please choose all that apply)
   ( ) Walk
   ( ) Bike
   ( ) Car
   ( ) Public Transport

5) When do you most often use the green space?
   ( ) Weekdays
   ( ) Weekends
   ( ) Holidays
   ( ) Special occasions
   ( ) Other

6) Who do you normally visit green spaces with? (Please choose all that apply)
   ( ) Alone
   ( ) With Family
   ( ) With friends
   ( ) With Pets
   ( ) With kids
   ( ) With acquaintance
   ( ) With members of some group/association
   ( ) Other
7) What is your purpose in visiting green spaces? (Please choose all that apply)
   ( ) Physical activity/exercise
   ( ) Visiting with pets or children
   ( ) Social activities/events/gatherings
   ( ) To meet new people and make connections
   ( ) Passive enjoyment (e.g., resting, meditation)
   ( ) For solitude and introspection
   ( ) For escape from social/personal pressure
   ( ) Therapy (e.g., visiting nature areas as recommended by doctors)
   ( ) Other (Please state): ________________________________
Appendix L: IRB Approved - Park Preference Questionnaire

Please look at the following park images carefully. These are images taken from the same urban park and the landscape design elements of the park have been modified.

Image A

Image B

Image C
1. How familiar are you with the park shown in the picture?
   ( ) Very familiar  ( ) Somewhat familiar  ( ) Not familiar at all

2. If you are familiar with this park, how many times have you visited this park?
   ( ) Once  ( ) 2-5 times  ( ) More than 6 times
   ( ) Not Applicable  (Choose this only if you are not familiar with this park)

3. Please rank the above images in order of how appealing the are to you.
   (1) Very Appealing, (2) Somewhat appealing, (3) Not appealing at all
   Image A: ( )  Image B: ( )  Image C: ( )

4. Let's talk about the park image that was the most appealing to you: Image ( )
   The park is comprised of a number of different landscape elements. Which of these elements did you like the most in the image?
   ( ) Vegetation/greenery
   ( ) Water element
   ( ) Slope and landform
   ( ) Skyline
Appendix M: IRB Approved - Semi-Structured Interview Guide

A. Natural distractions:

The first thing I’d like to talk about is “natural distractions.”

Natural distractions are things that can be viewed or experienced that capture your attention and take your mind away from negative thoughts or stress that you experienced at the beginning of the session. Natural distractions have an impact on your emotional state – whether it’s positive or negative.

1. Can you describe the virtual urban park setting you just saw using the HMD?
2. Can you name the features/elements of nature that you noticed in the park setting?
3. Were there any particular features/elements that you liked? Explain why.
4. Do you think these features/elements made you feel better in any way? Elaborate how these elements made you feel.
5. Were there any particular features/elements that you did not like? Explain why.
6. Do you think these features/elements made you feel worse in any way? Elaborate how these elements made you feel.

7. Water feature:
   a) Did you notice the water feature in the park?
   b) Was it appealing to you? On a scale of 1 to 5, please tell us how appealing the water feature was for you, with 1 being "not appealing at all" and 5 being "very appealing."
   c) Would you have liked a different type of water feature? Please elaborate.

8. Landform:
   a) Did you notice the landform in the park?
   b) Was it appealing to you? On a scale of 1 to 5, please tell us how appealing the landform was for you, with 1 being "not appealing at all" and 5 being "very appealing."
   c) Would you have liked a different landform? Please elaborate.

9. Vegetation:
   a) Did you notice the vegetation in the park?
   b) Was it appealing to you? On a scale of 1 to 5, please tell us how appealing the vegetation was for you, with 1 being "not appealing at all" and 5 being "very appealing."
   c) Would you have liked some different form/density of vegetation? Please elaborate.

10. Overall setting:
    a) Was the overall park setting appealing to you? On a scale of 1 to 5, please tell us how appealing the park was for you, with 1 being "not appealing at all" and 5 being "very appealing."
    b) Would you have liked to include any natural/designed features in this setting?
    c) Would you have liked to eliminate any natural/designed features in this setting?
B. Stress:

Now let’s talk about the urban park as it relates to the concept of stress.

1. Do you generally tend to feel more or less stressed when you are in a park as opposed to other public spaces?
   a) If more stressed, are there particular periods of time or activities in the park which are more stressful than others, or may bring about more stress?
   b) If less stressed, are there particular periods of time or activities in the park which seem to reduce your stress?
   c) How, if at all, does your stress level change while you are in the park?
   d) How can you tell?

2. Are there features within the urban park space that seem to help you with stress recovery?
   a) What is one such feature?
   b) What is it about this feature within the park that helps to reduce your stress level?
   c) How long do you tend to feel less stressed? Is it momentary? Lasting?

3. Is there another feature that seems to aid in stress recovery for you?

4. Are there features within the urban park space that seem to make you feel more stressed?
   a) What is one such feature?
   b) What is it about this feature within the park that tends to make you feel more stressed?
   c) How long do you tend to feel more stressed? Is it momentary? Lasting?

C. Healing Spaces:

1. Are there particular kind of natural environments that you like to visit when you are stressed or feeling low?
2. Do you prefer going to parks that have certain design elements? Or is it just being in the nature that helps you?
Appendix N: IRB Approved – Debriefing Script

Researcher (R1)- Post Treatment:

“You were not actually being evaluated or scored. You were not actually being recorded. Your performance is not compared to other participants. No analysis of your speech or math task performance with be conducted.

We are just measuring a naturally occurring stress hormone in the body called cortisol and want to see how this hormone level changes when you spend time outdoors, especially in nature. For this, it is important for us to increase your stress level and then see how these levels drop when exposed to different environments. That’s why we have been collecting saliva samples from you.

We are sorry that we didn’t tell you the truth about everything, but if we had, the situation wouldn’t be stressful. You did a good job. Thank you for participating. You will be contacted in case you get picked in the drawing to receive one of the five gift cards.

Do you feel okay to go home/leave?”
Appendix O: Salimetrics Oral Swabs (SOS) usage instructions

Collection Methods: SalivaBio Oral Swab (SOS)

Approved for collection of saliva for analysis of: cortisol, alpha-amyrase (sAA), chromogranin A (CgA), cotinine, C-reactive protein (CRP), Interleukin-1 beta (IL-1β), Interleukin-6 (IL-6), melatonin, secretory IgA (SigA), testosterone, uric acid, and DNA.

Introductions: SalivaBio Swabs are intended for the collection of saliva samples for analysis. The SalivaBio Oral Swab (SOS) (Item No. 5001.02) is recommended for adult participants and those over the age of 6.

SOS Universal Cautions:
- Use only as directed.
- This device is packaged clean, not sterile.
- A copy of this caution note or the instruction sheet must be distributed to each device user.
- This device is not a toy and is intended for collection of saliva.
- Do not use this device for children under the age of 6, as the device may represent a choking hazard for children.
- Store out of the reach of children.

Materials Needed:
- SalivaBio Oral Swab, 10x30mm (Item No. 5001.02)
- Swab Storage Tube, 17x100mm (Item No. 5001.05)
- Bar-coded labels (Item No. 5009.07)
- 4" swab storage tube boxes (Item No. 5023.00)
- Optional: 5 cc syringe (Item No. 5015.02)
- Optional: 2 ml cryovials (Item No. 5002.01-06)

Instructions for Use:

1. Peel back protective package and remove the SOS.

2. Remove SOS from outer packaging and place into proper mouth location based on research question (normally under the tongue). Studies show that placing absorbent swabs in different areas of the mouth can influence both the amount of sample volume collected and the composition of the analytes in the sample. Therefore, we recommend that the SOS should not be moved around in the mouth during collection. Keep SOS in place for 1-2 minutes. (If collecting from the parotid glands in the cheek, saliva flow will be low, and collection time should be extended for up to 5 minutes to ensure adequate volume.)

⚠️ Flow rate may be difficult to estimate when collecting with this device due to its rapid absorption characteristics. See Effects of Mouth Location and Flow Rate on Salivary Analyses in the Saliva Collection Handbook (online at www.salimetrics.com).

⚠️ Be sure you have collected enough volume. Too little volume may make it impossible to perform the test.

3. Remove SOS from mouth and immediately use one of the following procedures for storing the sample:

a. If storing swab in swab storage tube for centrifugation in lab
   1. Remove cap and insert the swab into the tube insert ("basket") of the swab storage tube (SST).
   2. Recap SST tightly. Note: Do not throw away any parts of the tube assembly.
b. If assessing volume in the field or using compression to remove the sample

1. Remove plunger from a 5 cc syringe.
2. Insert the swab into the syringe barrel.
3. Replace plunger into syringe and squeeze the swab to express the saliva into a cryovial.
4. Repeat collection procedure if additional volume is required.
5. Cap tube tightly. You may discard swab, unless further DNA analysis is to be expected.

Note: The compression method recovers slightly less saliva volume from the swab than centrifugation, but allows the volume recovered to be assessed.

4. Label the exterior of the SST horizontally with an identifying, bar-coded, cryo-label (*required for samples that will be sent to Salimetrics SalivaLab). Do not use paper labels – they will fall off when frozen.

Sample Handling and Processing (As described in the Saliva Collection Handbook):

- Immediately after collection, freeze samples at or below -20°C. If freezing is not possible, refrigerate immediately at 4°C and maintain at this temperature for no longer than necessary (ideally less than 2 hours) before freezing at or below -20°C (temperature of a regular household freezer).
- Samples stored for more than 4 months should be frozen at -80°C.
- Freeze-thaw cycles should be minimized for some analytes. It is critical that storage conditions are researched prior to initiation of sample collection.
- If processing samples in-house prior to freezing, centrifuge the storage tube for 15 minutes at 3000 to 3500 rpm (1800 g) to extract the saliva. You may discard swab basket and swab unless further DNA testing is expected. Keep SST in upright position. Recap tube and proceed with freezing.
- It is recommended that tubes be organized into storage boxes (7x7 grids, 49 tubes) before storing or shipping.

NOTES:

- The measurement of many analytes is influenced by saliva flow or production rate. We advise recording the length of time the swab is in the mouth, and recording the volume (or weighing the swab in the storage tube before and after collection, in order to estimate volume by weight). Saliva flow rate is indexed in units of mL/min. This information can then be used as a statistical covariable or to express the assay results as a secretion or output rate (units/min). In order for the flow rate estimate to be accurate, however, the swab must be removed from the mouth before it reaches saturation. (The average maximum volume is 2 mL.)
- Samples can be frozen in the swab for up to 6 months. However, we recommend samples are expressed or centrifuged to remove saliva from swab collections as soon as possible and prior to freezing at temperatures of -20°C or below in order to minimize freeze-thaw cycles.
- Investigators using saliva samples collected with swab devices for analytes other than those approved by Salimetrics do so at their own risk.
- SOS may cause temporary dryness of mucosal membrane or oral cavity.

References

- References are available online at http://salimetrics.com/collection-system/adult-oral-swap
Appendix P: Salimetrics- Salivary Alpha-Amylase Kinetic Enzyme Assay Kit Information

INSTRUCTIONS FOR USE (IFU)

INSTRUCTIONS FOR USE (IFU)

www.salimetrics.com/fu/1-1902.pdf
Mobile Devices: A PDF viewer is required
to view this kit insert

In an effort to reduce waste, IFU are now
available electronically or mailed upon request.
To view all protocols visit:
www.salimetrics.com/salivary-assay-kits

Salivary α-Amylase
Kinetic Enzyme Assay Kit
1-1902, 1-1902-5

For Research Use Only
Not For Use in Diagnostic Procedures

SUPPORT INFORMATION
Website: www.salimetrics.com
Technical Service: support@salimetrics.com
Phone: 800.790.2258

KIT LOT NUMBER 1601505
KIT EXPIRATION DATE 2016-10-08

HIGH CONTROL RANGE 273.77 U/mL ± 68.44
LOW CONTROL RANGE 22.55 U/mL ± 9.02

NOTE: The control ranges established at Salimetrics are to be used
as a guide. Each laboratory should establish its own range.

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<th>Kit Components</th>
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<th>Lot Number</th>
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<th>5pk Kit Quantity</th>
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Approved by/date: [Signature]

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814.234.7748 • Fax 814.234.1608 • www.salimetrics.com
Version 2 Effective 4/28/15

282
## Appendix Q: Salimetrics- Salivary Cortisol Enzyme Immunoassay Kit Information

### INSTRUCTIONS FOR USE (IFU)

In an effort to reduce waste, IFU are now available electronically or mailed upon request. To view all protocols visit: www.salimetrics.com/salivary-assay-kits

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### Expanded Range

High Sensitivity Salivary Cortisol Enzyme Immunoassay Kit

1-3002, 1-3002-5, 1-3002-25

For Research Use Only
Not For Use in Diagnostic Procedures

### SUPPORT INFORMATION

Website: www.salimetrics.com
Technical Service: support@salimetrics.com
Phone: 800.790.2258

### Control Range

<table>
<thead>
<tr>
<th>HIGH CONTROL RANGE</th>
<th>LOW CONTROL RANGE</th>
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</thead>
<tbody>
<tr>
<td>1.011 µg/dL ± 0.026</td>
<td>0.037 µg/dL ± 0.015</td>
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NOTE: The control ranges established at Salimetrics are to be used as a guide. Each laboratory should establish its own range.

### Table: Kit Components

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Approved by (date): [Signature]

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