

# Content

Abstract.....	i
Resumen .....	v
Resum.....	ix
Acknowledgements .....	xiii
Content.....	xv
List of Figures .....	xix
List of Tables .....	xxi
Chapter 1. Introduction .....	1
Motivation .....	1
Virtual reality set-ups: formats, displays and interfaces .....	2
Navigation in Virtual Reality.....	4
Sense of presence.....	5
Virtual Reality in Human Behaviour Research.....	6
Implicit measures and the neuroscience approach .....	7
Affective computing and emotion recognition systems .....	10
Affective computing and Virtual Reality.....	11
The validity of Virtual Reality in human behaviour research .....	14
Objectives .....	15
Thesis structure.....	16
Chapter 2. Affective computing in virtual reality: emotion recognition from brain and heartbeat dynamics using wearable sensors .....	17
Abstract.....	17
Introduction .....	18

---

Material and methods.....	21
Experimental context.....	21
Participants.....	22
Set of Physiological Signals and Instrumentation.....	23
Stimulus elicitation.....	23
Signal processing.....	27
Feature reduction and machine learning.....	30
Data availability.....	32
Results.....	32
Subjects' self-assessment.....	32
Arousal classification.....	33
Valence classification.....	35
Discussion.....	37
Chapter 3. Real vs. immersive-virtual emotional experience: Exploiting psycho-physiological patterns in a free exploration of an art museum.....	41
Abstract.....	41
Introduction.....	42
Materials and Methods.....	45
Experimental design.....	45
Stimulus Elicitation.....	46
Participants' Eligibility and Group Homogeneity.....	51
Physiological Signals and Instrumentation Set.....	52
Signal Processing.....	53
Data Fusion and Pattern Recognition.....	56
Results.....	59
Subjects' Self-assessment.....	59
Emotion Recognition Classification.....	60
Real vs. Virtual Classification.....	61
Discussion and Conclusion.....	62
Supporting information.....	68
IAPS experimental protocol.....	68
Physiological signal segmentation and synchronization.....	68
Chapter 4. Navigation comparison between a real and a virtual museum: time-dependent differences using a head mounted display.....	73
Abstract.....	73

---

Introduction .....	74
Material and methods.....	76
Participants.....	76
Physical museum.....	77
Virtual museum.....	78
Signal synchronization .....	81
Spatial segmentation and analysis.....	82
Results.....	82
Self-assessment: presence and cybersickness.....	82
Heatmaps.....	83
Length of visit time and percentage of area explored.....	84
Discussion.....	86
Conclusions .....	89
Chapter 5. Discussion .....	91
Immersive VR as an emotion elicitation methodology.....	91
New affective computing methods using 360° immersive VR .....	92
The power of 3D real-world simulations for evoking emotions .....	93
Using psychological signals and machine learning in 3D VR .....	94
The influence of navigation in 3D environments .....	95
Chapter 6. Conclusion .....	97
Research activities .....	101
Associated projects.....	101
Research internships .....	101
Journal papers.....	102
Conference papers.....	102
Conference posters.....	103
References.....	105