

AI-Driven Biophilic Buildings for Wellbeing

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A brief overview of few related projects



Biophilic designs of educational buildings: Inspiration; Personality differences and traits; EEG;



Human Nature Interaction Behaviour Onions



Forest Bathing in Hospices



Innovate UK project 1: Digital Biophilic Display AI Curation and Generative Arts



Innovate UK project 2: Smart Building for Ageing Care



Heritage buildings and mental health nexus



Biophilic classrooms improve learning

Evidence base



Stress reduction → lower cortisol, decreased skin conductance, reduced blood pressure,



Attention restoration → improved focus, reduced fatigue



Mood & creativity → higher job satisfaction, lower absenteeism



Inspiration → Increased motivation, creativity, and productivity

PLOS ONE

RESEARCH ARTICLE

Exploring biophilic building designs to promote wellbeing and stimulate inspiration

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Abstract

Biophilic designs aim to promote health and wellbeing by incorporating nature-based features into internal and external built environments. Three theories have previously been proposed (i.e., *Recovery*, *Attention Restoration*, *Refuge*, and *Prospect*) regarding the impact of biophilic features on psychological and physiological health, but with little empirical evaluation. This current study tests these three existing theories, alongside a novel biophilic theory proposed in this paper, as that biophilic environments stimulate *inspiration*. A public survey was conducted, and participants completed an online stress-induction task followed by images of building interiors that systematically varied in perceived biophilic quality—ranging across four levels (from 0 = no clear biophilic features to 3 = very high biophilic features). Participants rated their psychological states associated with each of the proposed theories before and after each trial's stress-induction and biophilic phases. Results support a positive effect of exposure to biophilic design on self-reported psychological states (including inspiration), whilst designs without biophilic quality tended to have an adverse effect on psychological states. Furthermore, findings support the extension of the current three theories to include the impact of biophilic designs on stimulating inspiration.



OPEN ACCESS

Citation: Xing Y, Stevenson N, Thomas C, Heym N, Hardy A, Knight A, et al. (2025) Exploring biophilic building designs to promote wellbeing and stimulate inspiration. PLoS ONE 20(3): e0317372. <https://doi.org/10.1371/journal.pone.0317372>

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1. Introduction

Exploring Biophilic Building Designs to Promote Well-being and Stimulate Inspiration

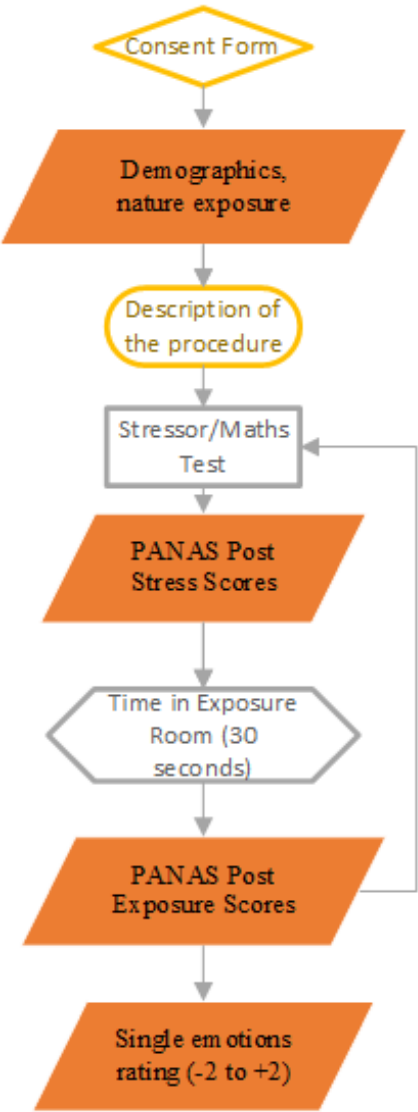
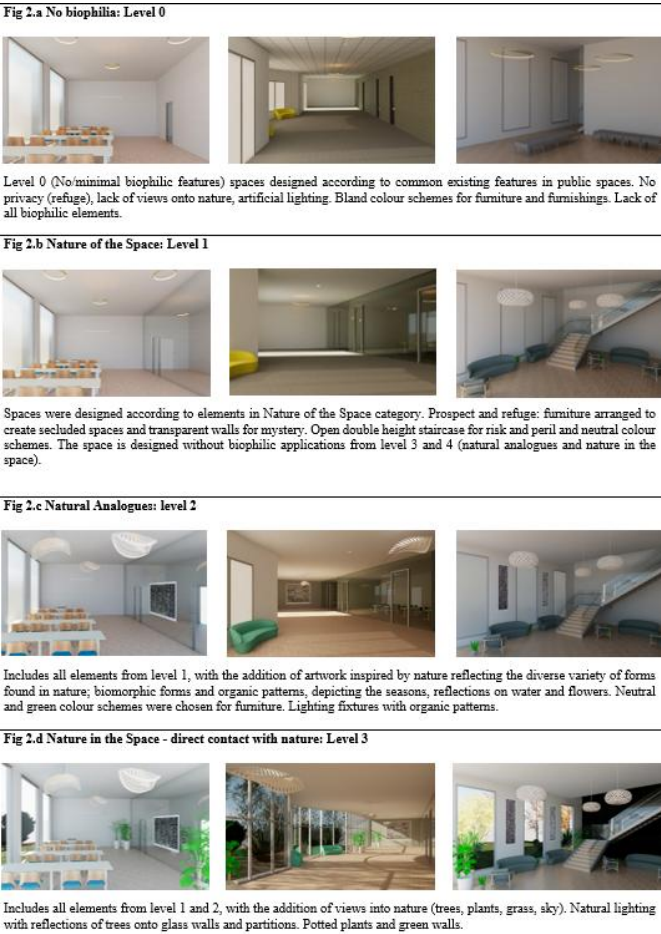
- Xing, et al, 2025, [Exploring biophilic building designs to promote wellbeing and stimulate inspiration](#), PloS one 20 (3), e0317372

Table 1. Demographics information of the participants

Characteristic	N=255 Sample exposed to the biophilic spaces	
Age Range	18-77 Years	
Biological Sex	Female	67%
	Male	22%
	Withheld	1%
Ethnicity	White	82%
	Black/African American	5%
	Asian	8%
	Other/ declined	4%
Environment Growing Up	Much More Nature	18%
	A Little More Nature	20%
	Equal Nature and Urban	18%
	A little More Urban	18%
	Much More Urban	17%
Living Environment in Termtime	Much More Nature	13%
	A Little More Nature	21%
	Equal Nature and Urban	18%
	A little More Urban	22%
	Much More Urban	17%

Biophilia Theory		PANAS Items
Stress Recovery		Relaxed, Irritable
Attention		Attentive, Fatigued
Restoration		
Refuge	and	Self-assured,
prospect		Frightened
Inspiration		Inspired,
		Downhearted

Paper 1: Inspiration (Xing, et al, 2025)



1 of 14

PLOS ONE

RESEARCH ARTICLE

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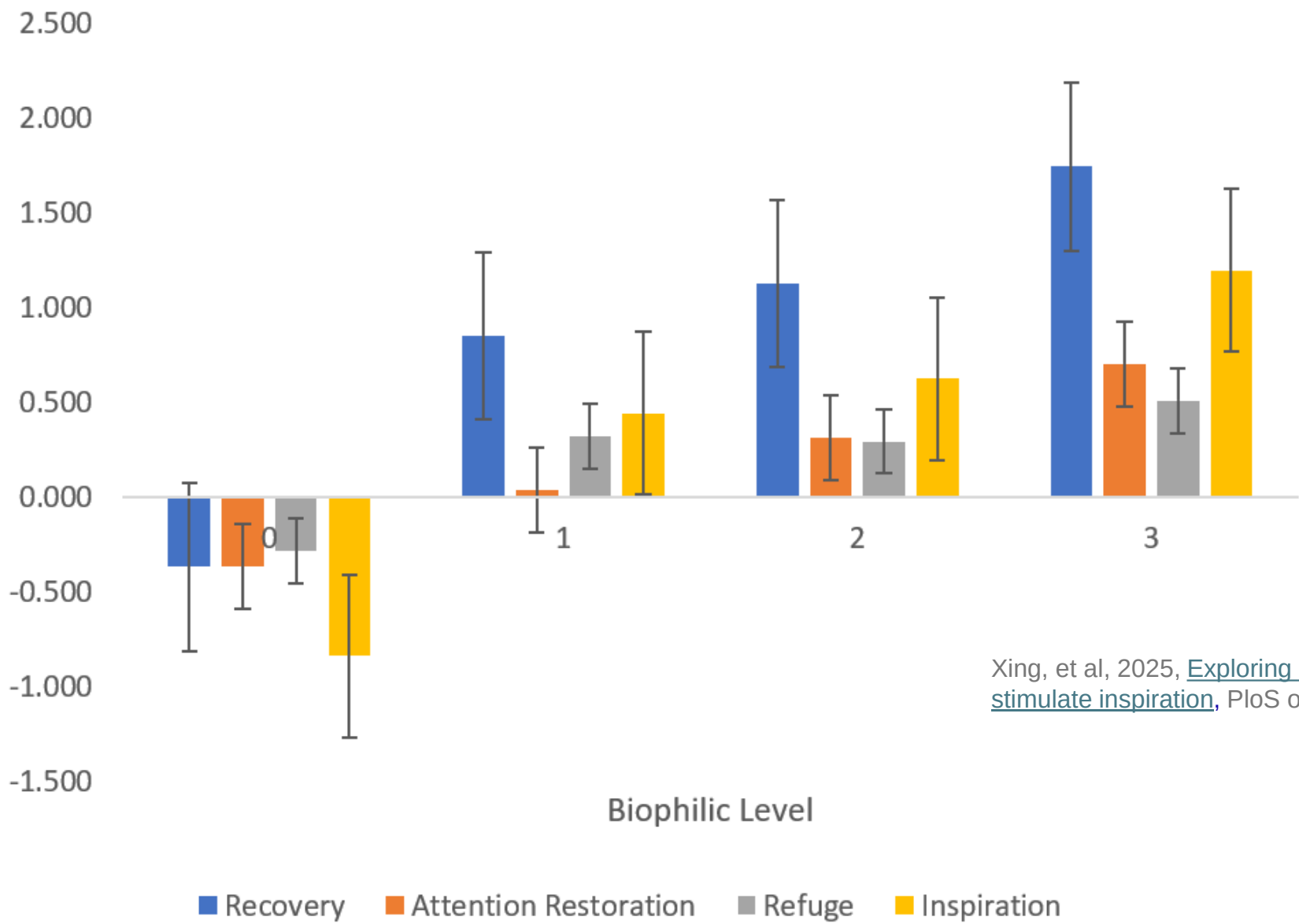
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Citation: Xing Y, Stevenson N, Thomas C, Heym N, Hardy A, Knight A, et al. (2025)

Paper 1: Inspiration

Estimated Marginal means Across Biophilic levels

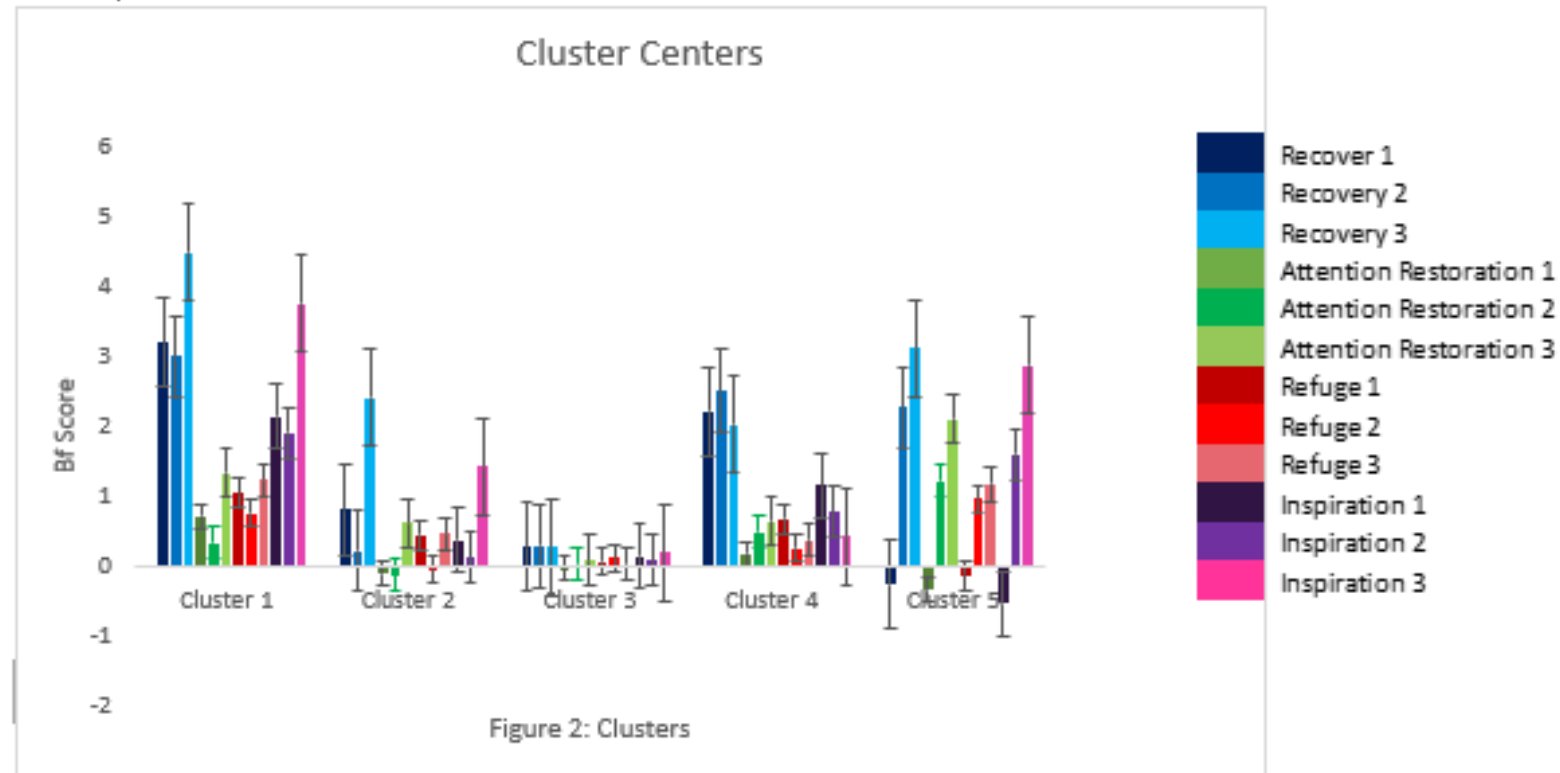


Xing, et al, 2025, [Exploring biophilic building designs to promote wellbeing and stimulate inspiration](#), PloS one 20 (3), e0317372

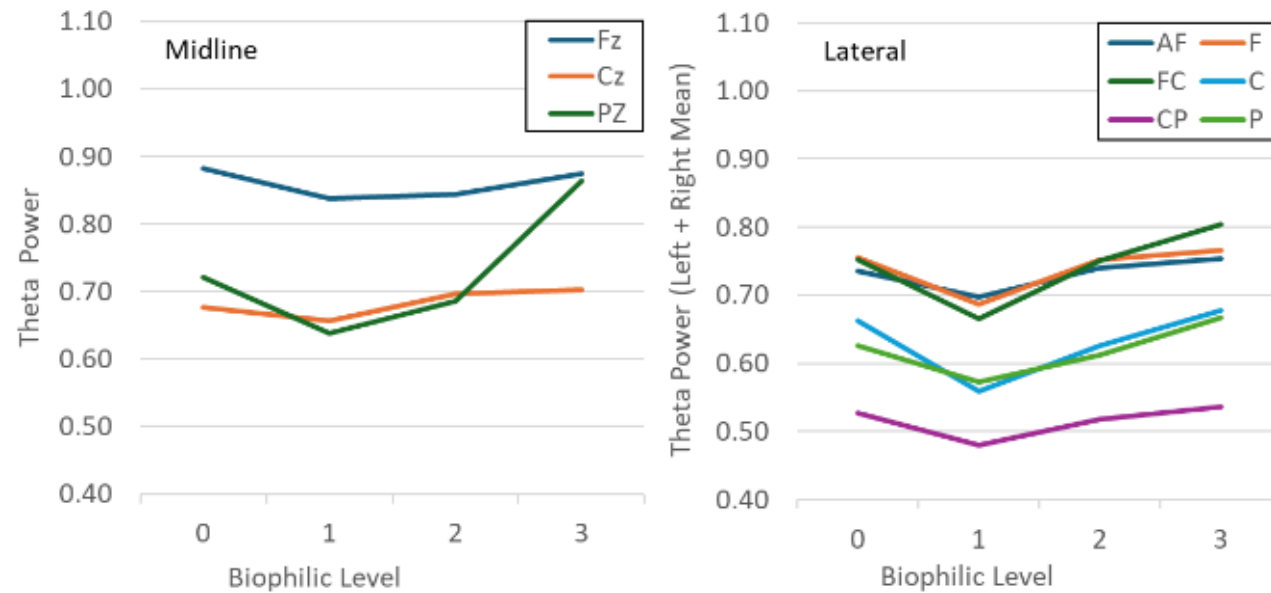
Paper 2: Personality

Exploring the potential of Biophilic Building Designs to Promote Well-being in Neurodivergent Groups

- **Autism-Spectrum Quotient (AQ-10;** Allison, Auyeung & Baron-Cohen, 2012)
- **The Strengths and Weaknesses of ADHD Symptoms and Normal Behaviour (SWAN)** scale (Swanson et al., 2012)
- **The Depression Anxiety Stress Scales (DASS - 21;** Lovibond & Lovibond, 1995)
- **The Nature Relatedness (NR; 21 items)** scale (Nisbet, Zelenski, & Murphy, 2009)
- **Negative Affect Scale (PANAS)** (Watson & Clark, 1994)



Paper 3: EEG Analysis



32-Channel EEG For Whole-Brain Sensing



*Means for subjective response (left panel, error bars show standard error of means) and **theta power** ($\mu V^2/Hz$, right panels) as a function of 0-3 biophilic features. Lateral theta power was recorded over anterior frontal (AF), frontal (F), frontocentral (FC), central (C), centroparietal (CP) and parietal (P) regions.*

In line with previous work (Chen et al., 2020; Rounds et al., 2020; Jung et al., 2023), increasing biophilic features were associated with increases in posterior and lateral theta power



FLEX 2.0

Beneficial effects on subjective mood and brain function of biophilic quality in university environments shown in virtual reality (15th ICDVRAT, Prague, Sumich, Thomas, Knight, Xing 2024)

Developing An AI-based Digital Biophilic Art Curation to Enhance Mental Health in Intelligent Buildings

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† These authors contributed equally to this work.

Emotional Label	p-Value (Recommendation System)	p-Value (Random Recommendation)
Relaxed, Calm	0.039 *	0.796
Proud, Grand	0.673	0.902
Nourished, Fulfilled	0.532	0.648
Attentive, Concentrating	0.201	0.405
Sad, Downhearted	0.007 *	0.268
Afraid, Frightened	0.108	1.0
Upset, Distressed	0.346	0.47
Inspired, Amazed	0.0002 *	0.013 *
Energised, Excited	0.053	0.318
Happy, Cheerful	0.022 *	0.694
Determined, Confident	0.252	0.272
Safe, Cosy	0.957	0.368
Ashamed, Guilty	0.601	0.748
Shy, Bashful	0.011 *	0.371
Hostile, Angry	0.114	0.414

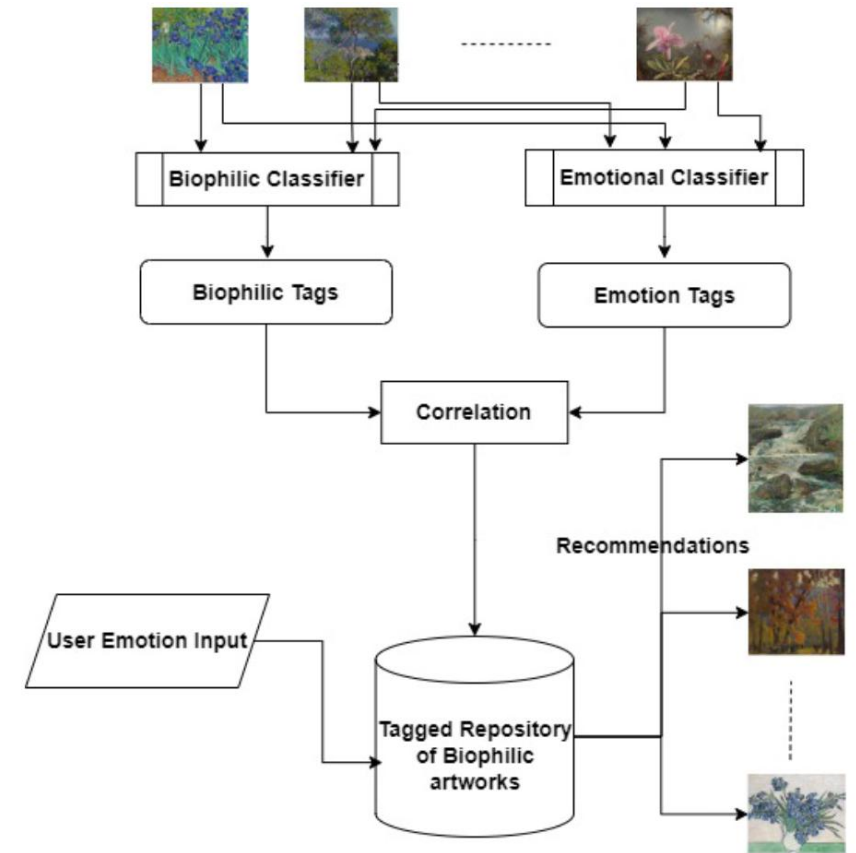
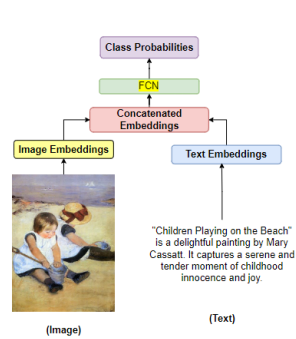
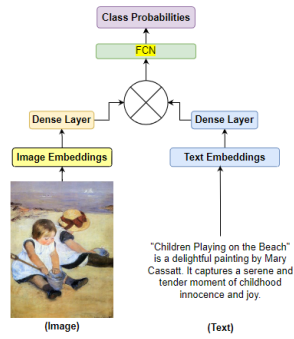


Figure 3. High Level Diagram of the Recommendation System.

Predicting Emotions Evoked by Artworks: A Study on Multi-Modal Approaches



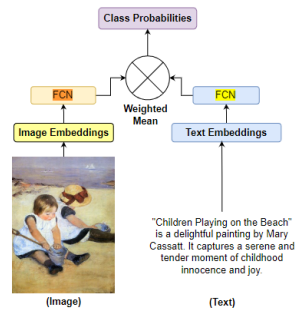
(a) Dual-stream Early Fusion Model



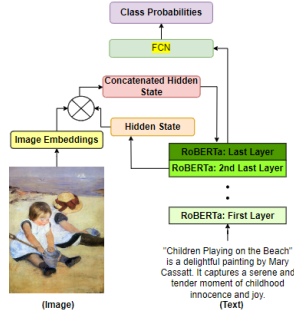
(b) Dual-stream Late Fusion Model



(a) Predicted Label: Happiness (Image Explanation)



(c) Dual-stream Ensemble Model



(d) Linear Probing Model

Fig. 4: High-Level Diagrams of Multi-Modal Models



(c) Predicted Label: Sadness (Image Explanation)

Predicting Emotions Evoked by Artworks: A Study on Multi-Modal Approaches

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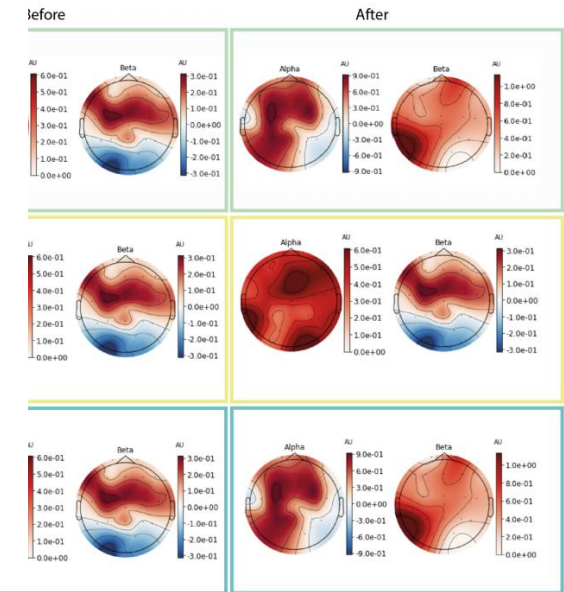
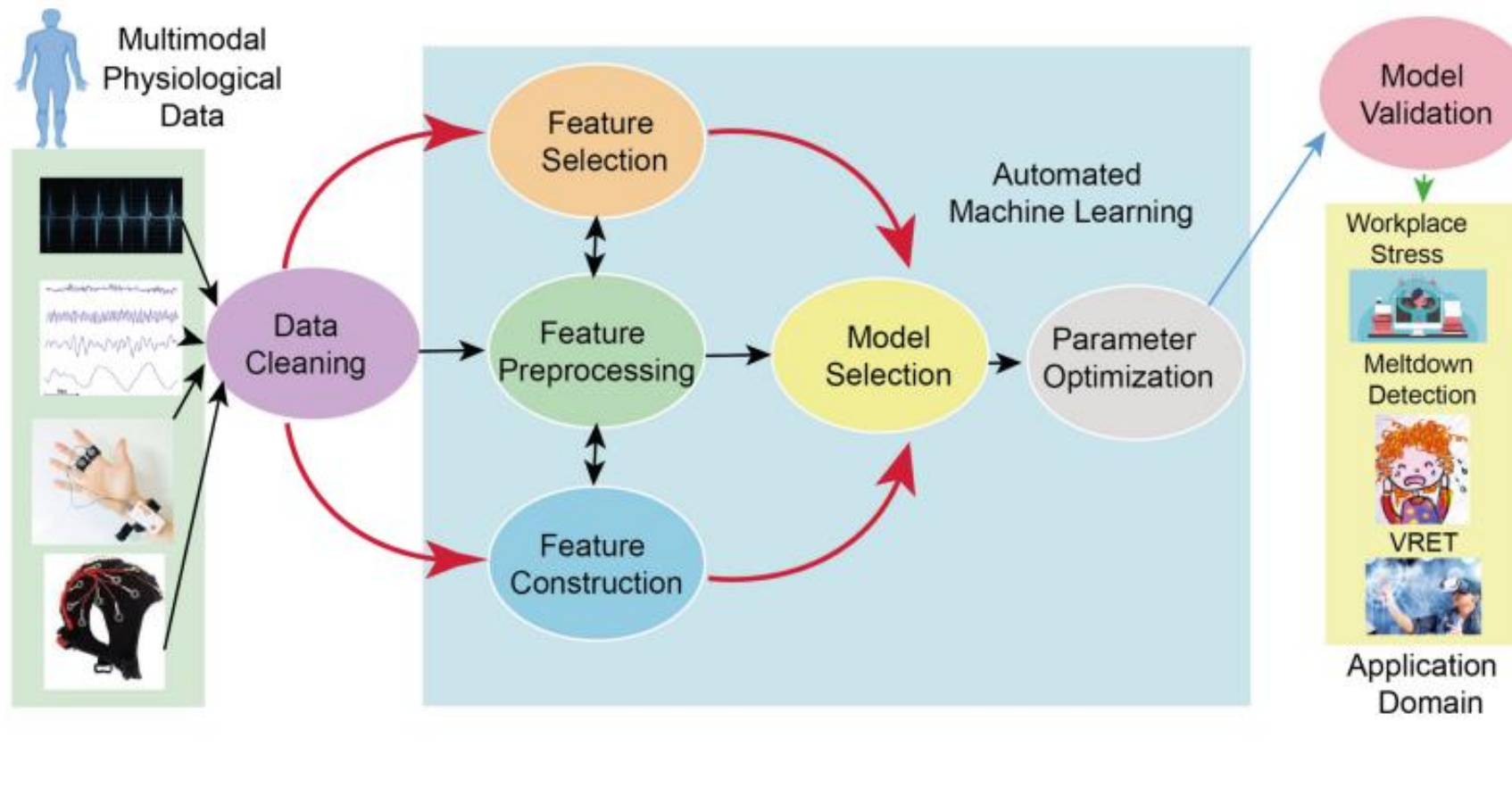
Artificial Intelligence eJournal

Children Playing on the Beach is a delightful painting by Mary Cassatt it captures a serene and tender moment of childhood innocence and joy

(a) Predicted Label: Happiness (Image Explanation)

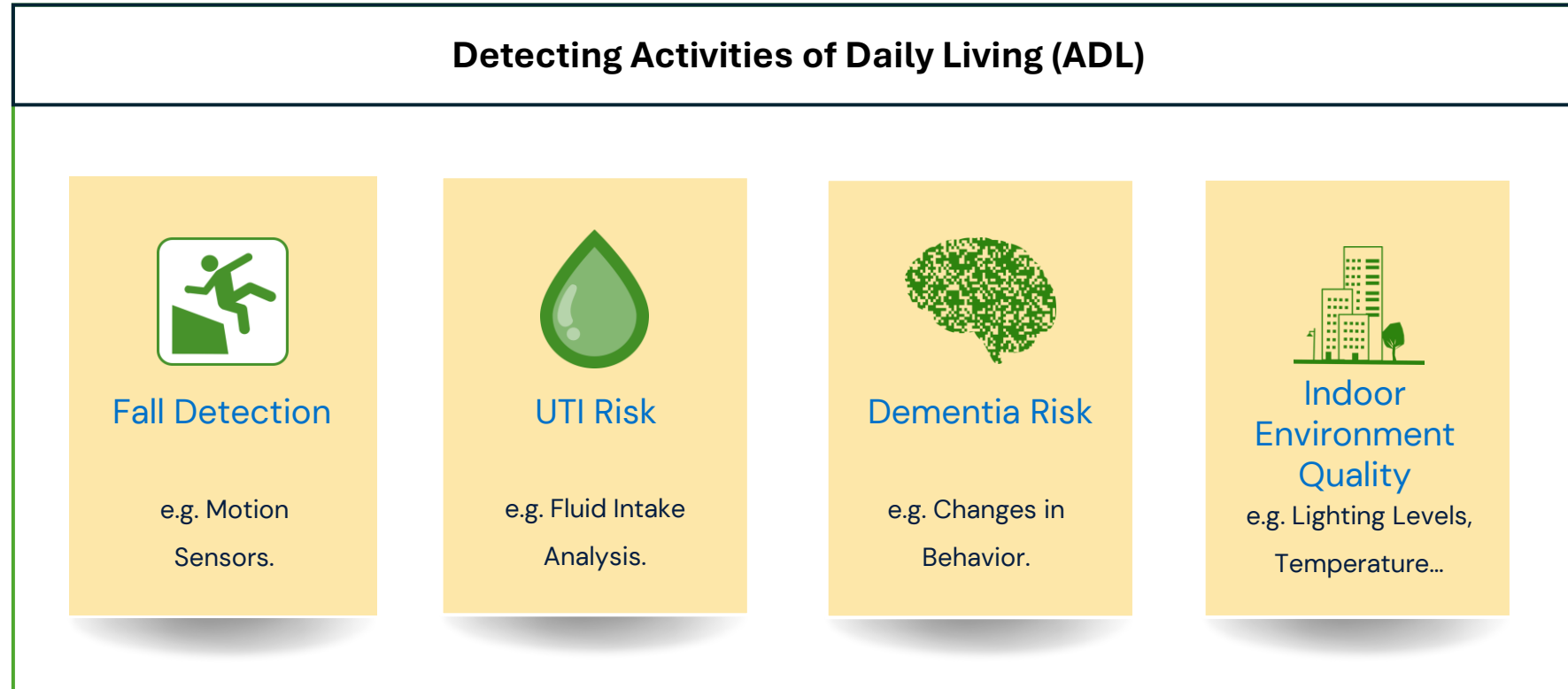
Jil ted is a poignant painting by Brit on Riviere, completed in 1887 It portrays a heart-wrenching scene of rejection and emotional pain In this painting, we see a man sitting on a chair, his posture reflecting dejection and despondency His gaze is down cast, his shoulders slumped, and his facial expression wrought with despair, possibly holding a letter of rejection in his hand Despite his sorrow, a loyal companion, his dog, stands beside him, offering silent comfort and solace in this moment of distress

(d) Predicted Label: Sadness (Text Explanation)

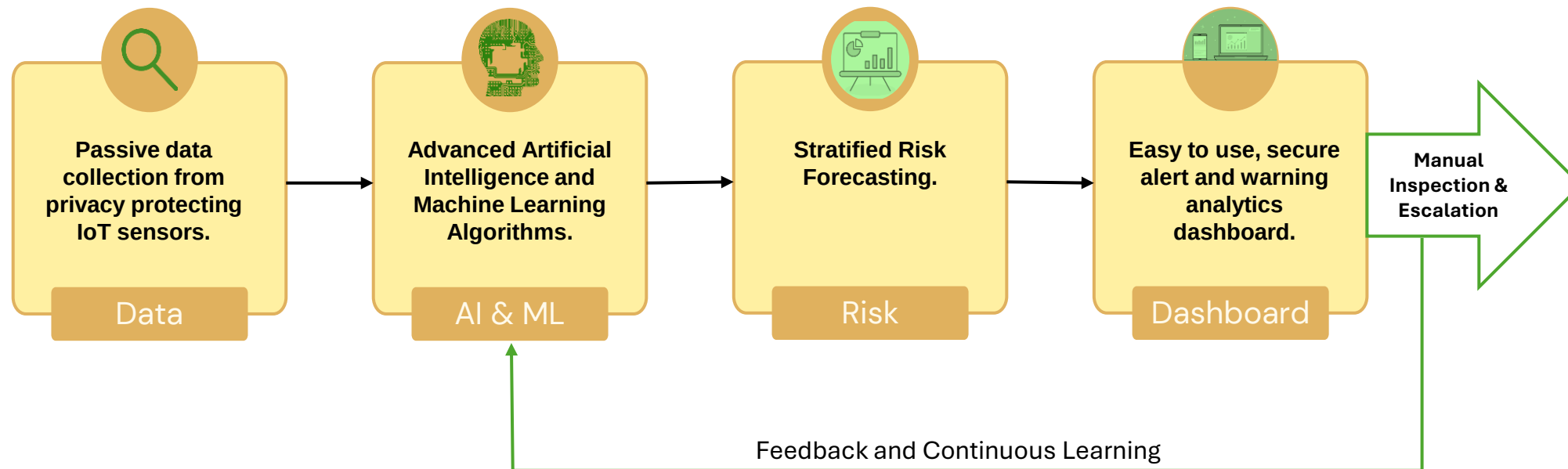


Industrial collaboration:

Smart Care homes redefined: AI-Driven People-Centric Care



Virtual Wards and Assisted Living



ADL Identification: Power Monitoring

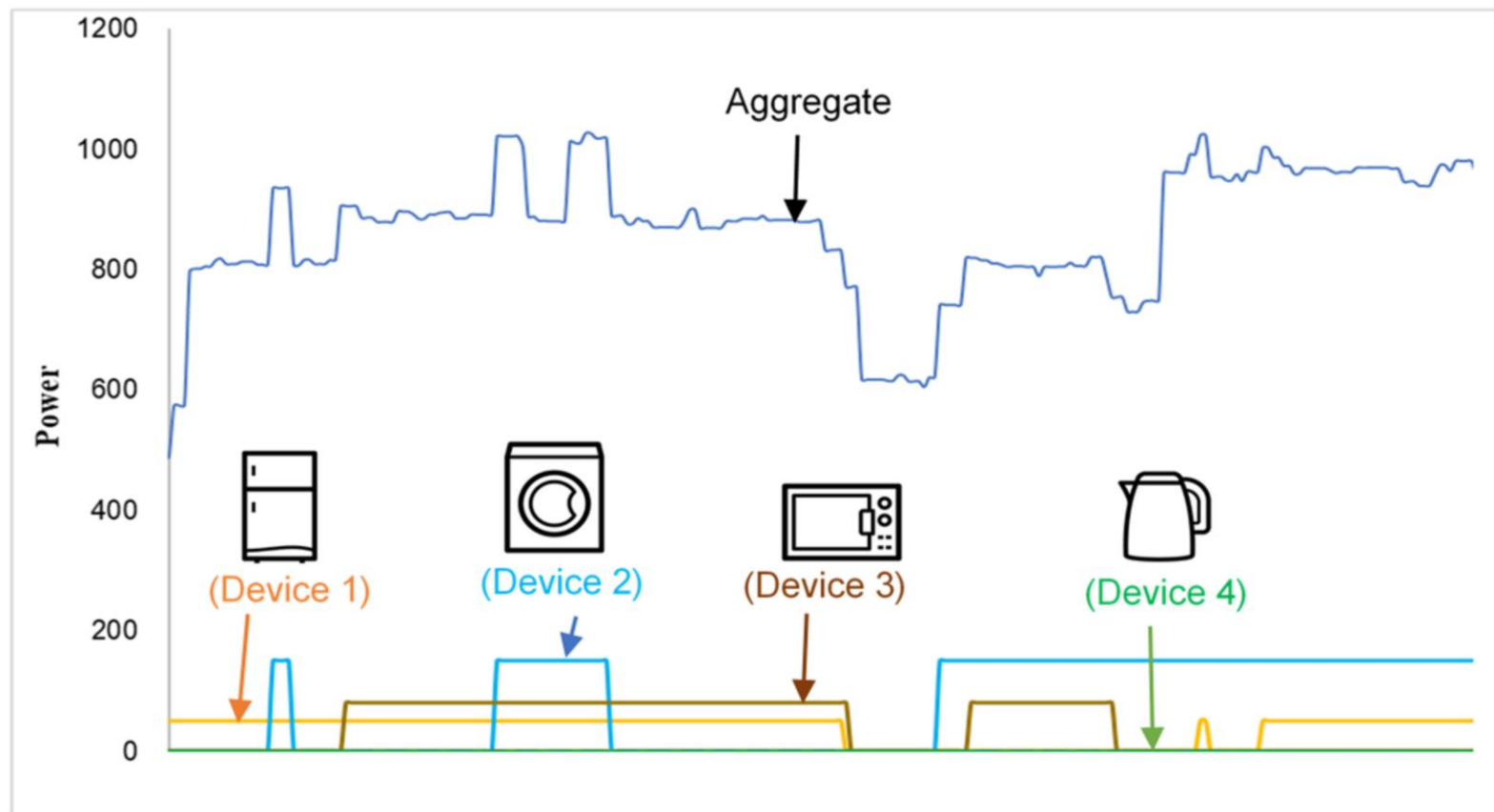


Figure 7: Power Monitoring profile for residential building
Sensors 2022, 22(11), 4036; <https://doi.org/10.3390/s22114036>

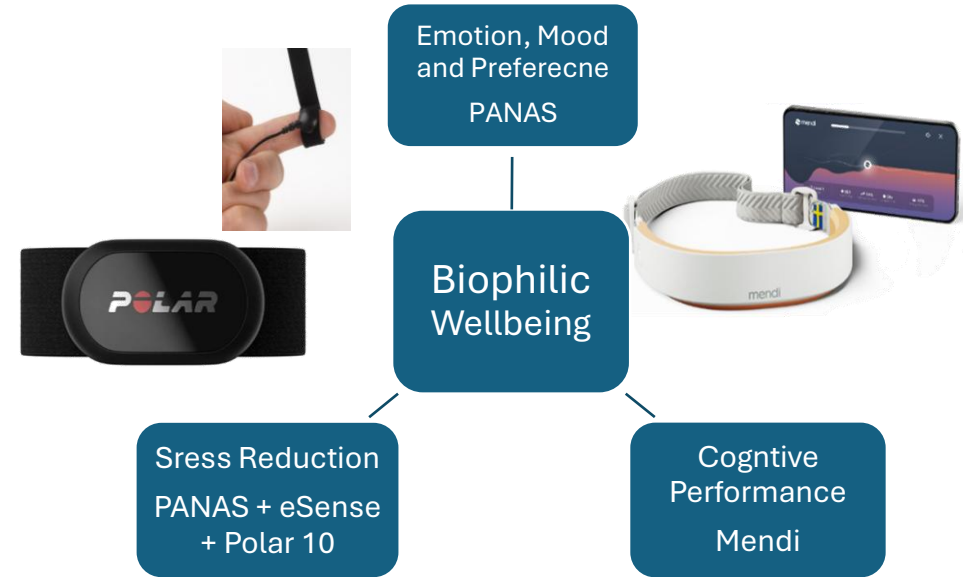
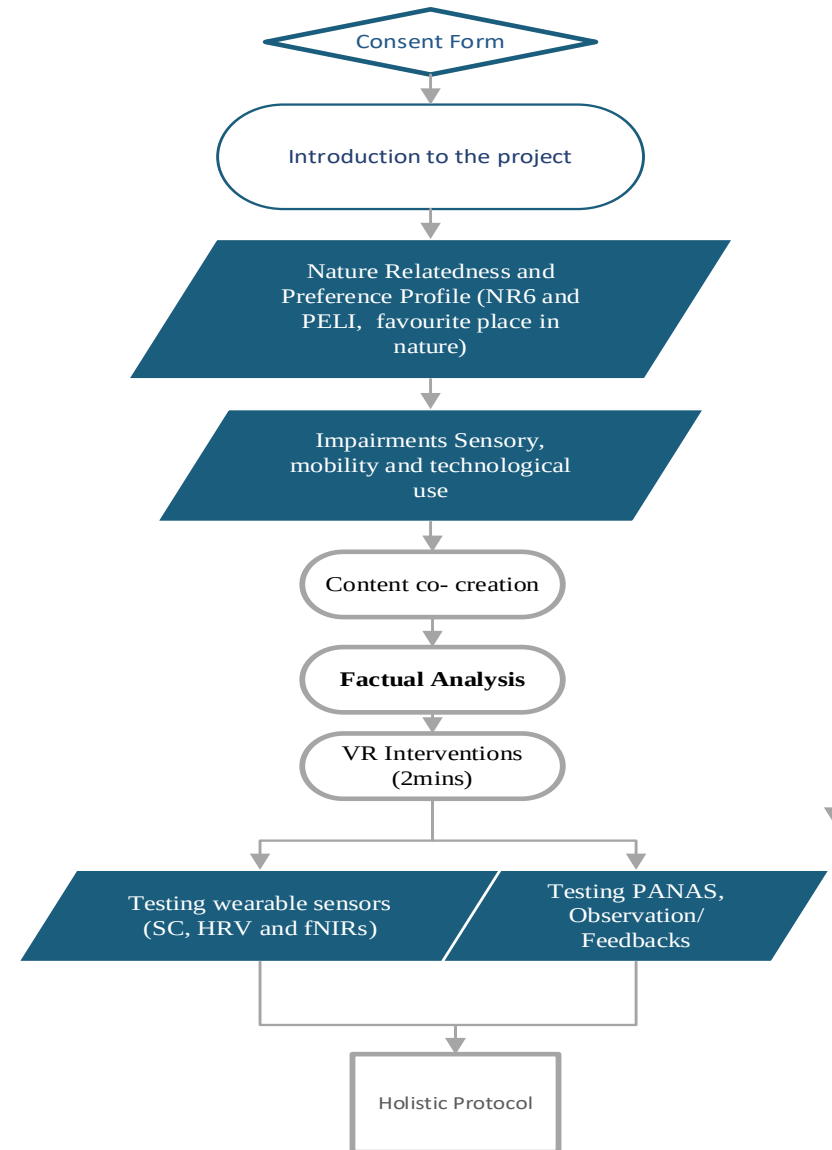
Biophilic Palliative Care



Complexity and Order - Natural Analogues

- Nature Preference Profile
- Scene taken with 360 camera

Pilot Study – Biophilic Therapy Monitoring



Thomas, Xing, 2024, [Existential Biophilic VR Therapy – Developing a Protocol for Care](#), The 15th International Conference on Disability, Virtual Reality, Prague



Initial results: Health and Wellbeing

SC Baseline	Level 1	Level 2
4	44	0
9	7	2
4	/	2

RMSSD Baseline	Level 1	Level 2
138.92	165.95	96.98
28.70	12.5	93.25

SDNN Baseline	Level 1	Level 2
90.68	126.55	92.31
19.31	14.13	77.83

eSense – Skin Co

0-5 = relaxed state
6-9= animated state
10+= stressed

Polar 10 - Heart Rate Sensor

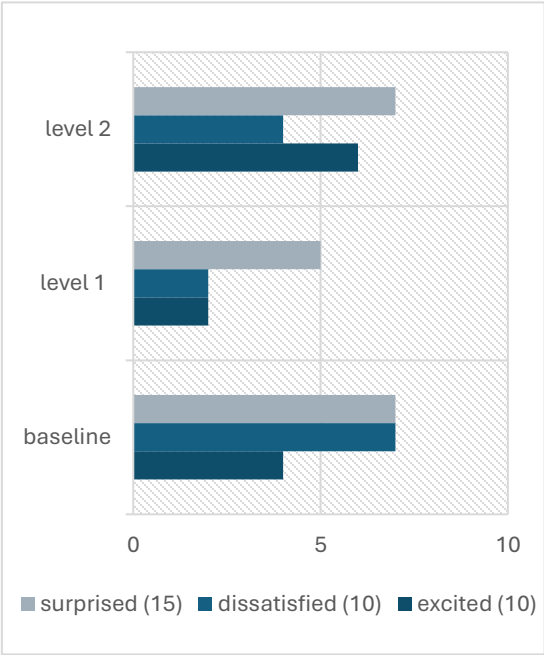
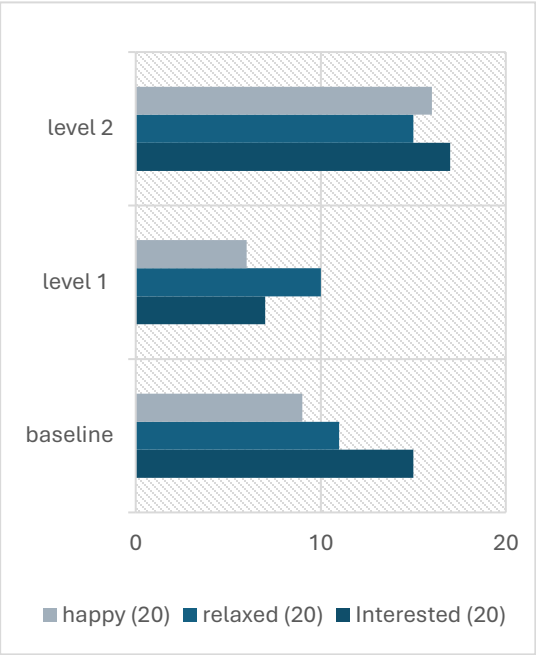
RMSSD - healthy range 19ms to 107

SDNN – healthy range + 100

50 to 100ms - compromised health

Below 50 – unhealthy

	Countryside scene	<u>Fd</u>	Woodland scene	<u>Fd</u>	Coastal Scenes	<u>Fd</u>
High Fd		1.70		1.71		1.75
Medium Fd		1.47		1.47		1.47

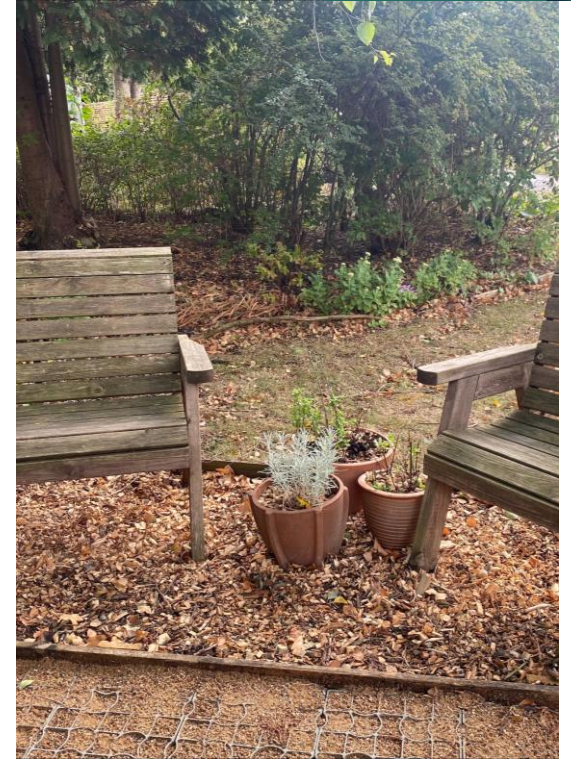


Forest Bathing in Hospices- On-going PhD research

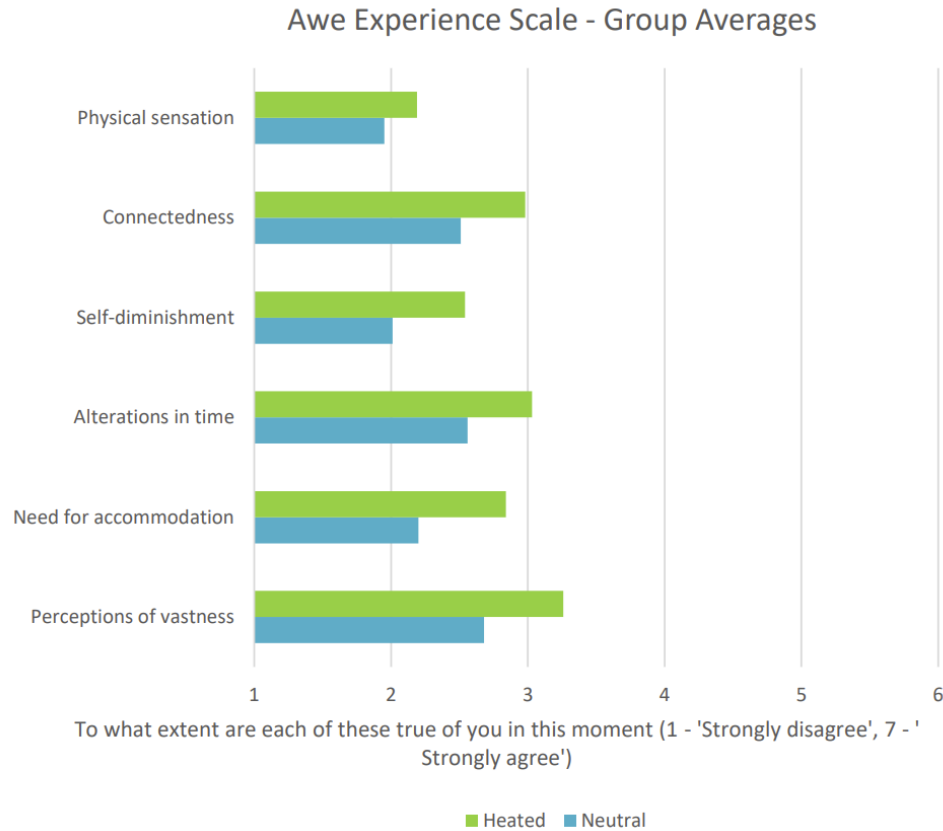


Quality of Life Indicators	Unguided		Guided	
	Pre	Post	Pre	Post
Warwick Edinburgh mental Wellbeing Scale	36.67 (8.19)	46.67 (7.57)	45.25 (6.96)	51.5 (10.25)
Inclusion of Self in Nature Scale	4.22 (1.20)	5.11 (0.78)	4.75 (1.04)	5.88 (0.64)
SNDD (HRV)	24.00 (18.18)	28.48 (23.31)	40.23 (16.39)	45.96 (18.23)

Biophilic Multi-Sensory Accessibility



Intelligent Heritage Buildings

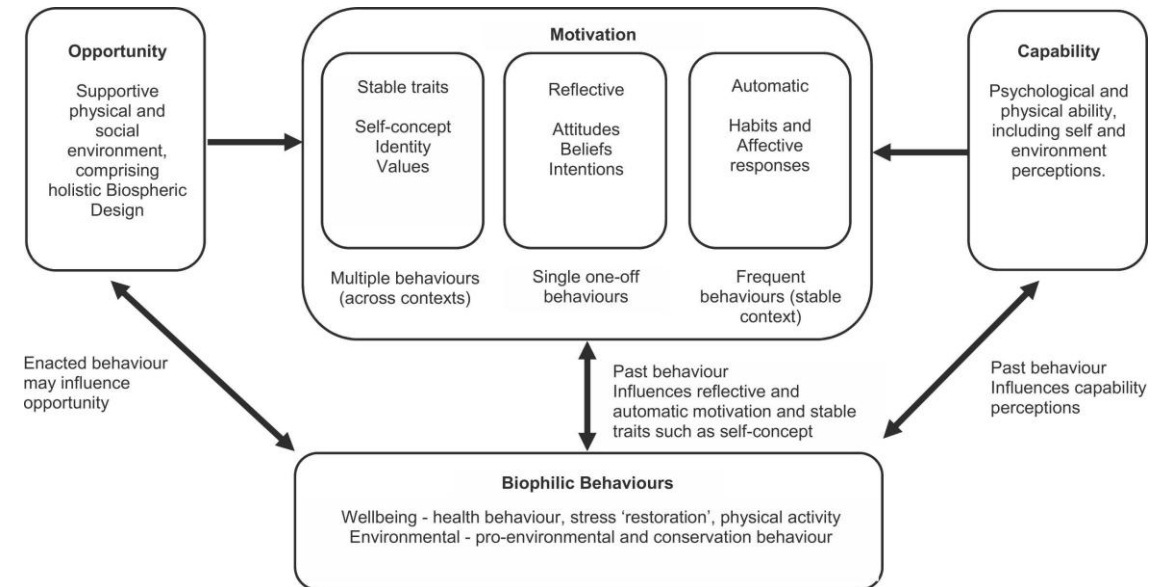
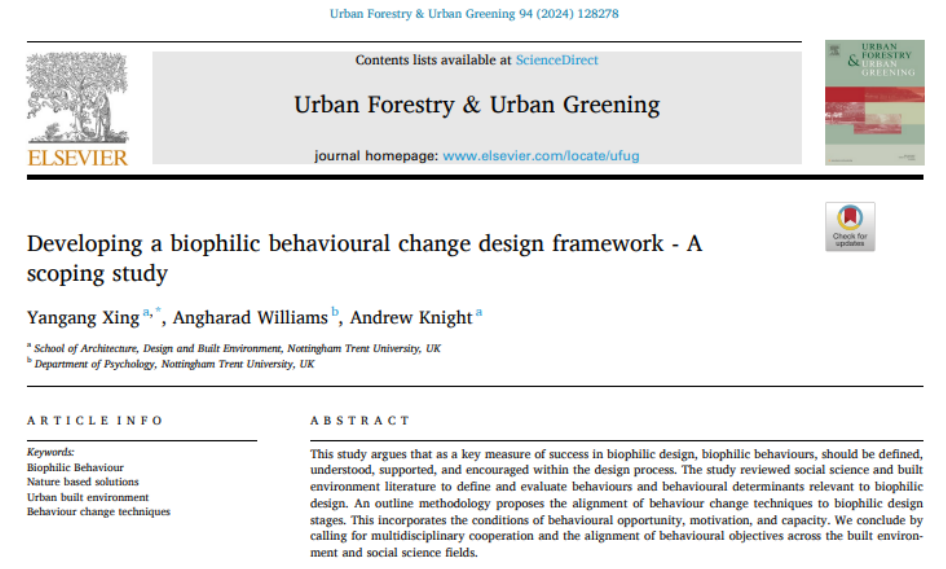
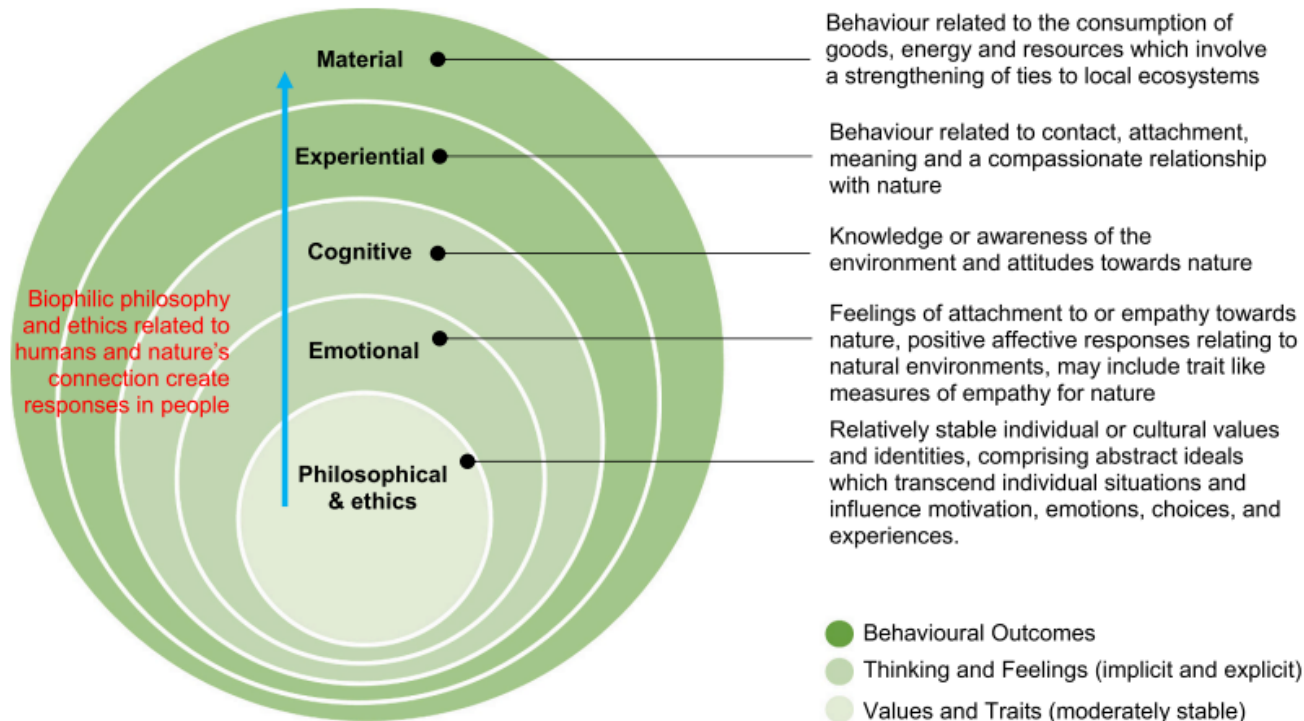


- Multiple sensory biophilic features and mental health
- No Harm Zero Carbon, thermal comfort and pipe organs
- Unlocking cultural heritage for inclusive urban regeneration



FIGURE 2: Fabrics in the interior.

Human Nature Interaction Onions (Xing, et al 2023)



Networks

- Charing Intelligent Buildings group
- Organizing international webinars
- Developing International collaborations



CIBSE
Intelligent Buildings

Thank you !

Please inform us of any case studies or research proposal
you would like to collaborate

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