

الاستهلال

(قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا عَلَّمْتَنَا

إِنَّكَ أَنْتَ الْعَلِيمُ الْحَكِيمُ)

سورة البقرة (32)

صدق الله العظيم

'Architecture is basically a container of something. I hope they will enjoy not so much the teacup, but the tea.'

Yoshio Taniguchi



Dedication

To my mother, the candle of my life.

To my father , who chosed to bear the hardships of expatriation to give his sons a better life.

To my brother , my second father ,who never spared on effort to support me when I needed him.

To my sisters ,who supported me a long the way.

To my friends who are the source of backup and strength.

To my professors, who are the source of my enlightenment .

To every body who ever prayed for my success.

Acknowledgments

“Be a scholar, if you can not, be educated, if you can not, love scientists, if you can not, do not hate them”

I thank God before anything for his great gifts and for giving me the will, the courage and strength to fulfill my goal.

My gratitude goes to Dr. Saleem Elzain who never spared an effort to teach and guide me during this work and for his patience and kind caring to this work.

I greatly thank (Dr. Saud Alsading and Dr.Ibrahim Nasr ,head of department of interior design ,sudan university) for the knowledge and guidance they gave for this work.

Thank to assistant lecture at the departments of interior design, sudan university , engineer:Wail who gave useful information and knowledge that had a great impact on the success of this work.

I am very grateful to my soulmate ,engineer:Hiba Gasim Elseed because of her -after God- I could obtain valuable resources those were not available in sudan to achieve this work.

Thank to the staff of “ Afraa Mall” engineers and employees for giving important information and guidance .

Thank to library of Faisal Islamic Bank for preparing the proper atmosphere for studying

I am very grateful to my friends (Aya Abdelrahman , Roa Arabi, Selwa Ali, Wafaa Fageerey, Eiman Musa and Raheeg Abdelhaleem) and (My uncle Osman Elbasha,My Aunt Hayat) for all the help and support they gave me .

Thank to every body who helped us with effort, a word or a pray.

Abstract

Interior architecture and its fundamentals and requirements , recently became attractive to a lot of specialists. those specialists know the importance of interior architecture and apply its fundamentals to the interior space so it satisfies the user's needs .

The research highlights the concept of interior architecture , its fundamentals and requirements .then the research shows how to apply those fundamentals to the malls design from the early stages so as to result into unique satisfying interior environment .

the problem of the research is that there is misunderstanding of what interior architecture is ,which results in lack of practice for its concepts and fundamentals , given attention from the early stages of design specially in designing malls as a service building that represents the urban image of the city

The study aims to identify interior architecture (its fundamentals , its elements and its practice). Also the study aims to develop that meaning in Sudan , and to make a specialized study about interior architecture in malls.

The study was based on descriptive analytical method which had been collected from scientific books , references, reports, information collected from personal knowledge and questionnaire . from literature review the basic standard of interior architecture and its fundamentals was formed understood also studying international examples and compare their application of those fundamentals and requirements on design of interior space of malls and try to use those applications in Sudan (to match our environment and society) . A case study has been made by the researcher in Khartoum to find out how far the concept of interior architecture and its fundamentals are applied in Sudanese malls , negative and positive points had been pointed out and the researcher studied those points and concluded recommendations .

The study found that there is a knowledge gap in the understanding of interior architecture which was not subject to science and methodology .the progress of the design of interior space of malls would reflect the importance of interior architecture' basic concepts and apply them in the interior space so as to enrich it and to make a remarkable space design. The design of the interior space of malls gives consideration to environmental aspects, functional aspects ,

The Interior Architecture Of Malls

materials, lightening ,colors , textures , ...etc. also adding the excitement to user's eye such as plants, fountains, lighting all those helps on attracting users.

The study concluded that Including interior architecture in academic Celebes of specialist department in universities , also Arranging competitions to encourage applying the interior architecture fundamentals to the design for unique malls, as a practice interior architecture must be involved from the early stages of the design process and Using well selected materials , colors and textures that meet the functional requirements and matches the culture and environment of Sudan.

المستخلص

ان معرفة العمارة الداخلية واساسياتها ومتطلباتها كتخصص معاصر اصبح جاذبا لكثير من ذوي الاختصاص الذين ادركوا اهميته وكيفية تطبيق اساسياته لاكساب الفراغ الداخلي قيمته وغناه حتى يفي بجميع متطلبات المستخدم ورغباته.

تناول البحث دراسة مفهوم العمارة الداخلية واساسياتها ومتطلباتها ثم تم عكس ذلك في المول وكيفية تطبيق هذه الاساسيات ومراعاتها في عملية التصميم ومنذ المراحل الاولى للوصول الى فراغ داخلي مميز ومبتكر للمولات يراعى فيه كل هذه الاساسيات.

تمثلت مشكلة الدراسة في الالتباس في فهم ماهية العمارة الدخلية والذي خلق فجوة في كيفية تطبيق متطلباتها وعناصرها في مراحل التصميم خصوصا في المول باعتباره نمط من انماط المباني الخدمية والذي يحتوي على أنشطة مختلفة ويعكس البيئة الحضرية للمدينة.

هدفت الدراسة الى التعريف بمصطلح العمارة الداخلية ومعرفة اساسياتها وعناصرها وازالة اللبس في المفهوم الحقيقي للعمارة الداخلية وكذلك تطوير هذا المفهوم في السودان بالاضافة الى كيفية خلق فراغ وظيفي يقابل كافة المتطلبات الوظيفية للمستخدمين مع معرفة مكونات الفراغ الداخلي للمول وبالتالي عمل دراسة متخصصة في العمارة الداخلية في المول.

اعتمدت الدراسة على المنهج الوصفي التحليلي والذي اعتمد على المعلومات العلمية الموثقة من الكتب والمراجع العلمية والتقارير وجمع المعلومات الميدانية من مقابلات شخصية واستبيانات حيث تم من الخلفية النظرية الوصول الى المعايير الاساسية للعمارة الداخلية ومتطلباتها وكذلك دراسة النماذج العالمية ومقارنة ما توصلت اليه الدول المتقدمة من تطبيق هذه الاساسيات في تصميم وتعزيز وتهيئة الفراغ الداخلي للمول ومحاولة تطبيق ذلك في السودان بما يتناسب مع بيئتنا ومجتمعنا وتم اختيار حالة دراسة في ولاية الخرطوم وجمع المعلومات عنها لمعرفة مدى تطبيق مفاهيم العمارة الداخلية واساسياتها فيه وعكس الجانب السلبي وكيفية الوصول الى حلول لتطبيق تلك المفاهيم بصورة واضحة وعملية حتى يتسنى لنا الخروج بتصاميم مدروسة ومبتكرة ومميزة في هذا الجانب.

توصلت الدراسة الى ان هنالك فجوة معرفية عن ماهية العمارة الداخلية والتي لم تخضع لاسس دراسية ومنهجية. كذلك فهم المتطلبات الفراغية والوظيفية بصورة تفصيلية يؤدي الى تلبية رغبات المستخدم وبالتالي الوصول الى رضى وراحة المستخدم. وان التقدم والتطور في العالم في تصاميم الفراغ الداخلي للمولات يعكس مدى الوعي بأهمية معرفة اساسيات العمارة الداخلية وعكسها داخل الفراغ الداخلي واثراءه والخروج بتصميم فراغ مميز يراعى فيه كل الجوانب التي من شأنها ان تعزز وتقوي الفراغ الداخلي بيئياً ووظيفياً من مواد واضاءة والوان وخامات وغيرها. كذلك اضافة عنصر الاثارة والتشويق من وسائل الحركة والعناصر البصرية التي تضيفي الراحة لعين المستخدم من نباتات ونوافير واضاءة كلها تساعد على جذب المستخدمين.

أوصت الدراسة بادخال العمارة الداخلية في المناهج الاكاديمية في الجامعات كتخصص منفصل وعمل دورات تثقيفية بذلك. كذلك يجب التشجيع على عمل تصاميم مبتكرة للمولات يتم تصميمها وتطبيق هذه الاساسيات فيها وعمل مسابقات تصميمية لتدعيم هذا الجانب بالاضافة الى اهمية الدراسات التفصيلية منذ المراحل التصميمية الاولى للفراغات الوظيفية ومعرفة متطلبات كل فراغ وكيفية تطبيقها والطرق المبدعة في اختيار الالوان والخامات والاضاءة بما يتماشى مع ثقافة المجتمع السوداني ومتطلباته.

Table Of Contents

| No | Title | Page No |
|--|--|---------|
| - | الاستهلال | I |
| - | Dedication | III |
| - | Acknowledgments | IV |
| - | Abstract | V |
| - | المستخلص | VI |
| - | Table Of Contents | VIII |
| - | List Of Figures | XII |
| - | List Of Tables | XVII |
| - | Definitions Of Terms | XVII |
| Chapter One Introduction | | |
| 1.1 | Introduction. | 2 |
| 1.2 | Problem Statement. | 2 |
| 1.3 | Research Importance. | 2 |
| 1.4 | Research Objectives. | 2 |
| 1.5 | Research Hypotheses. | 3 |
| 1.6 | Research Methodology. | 3 |
| 1.7 | Research Limits. | 3 |
| 1.8 | Research Obstacles. | 3 |
| Chapter two Literature Review | | |
| 2.1 | Introduction. | 5 |
| 2.2 | Background | 5 |
| 2.3 | Definition of the interior architecture. | 5 |
| 2.4 | The Fundamentals of interior architecture. | 7 |
| 2.4.1 | Site and function. | 8 |
| 2.4.2 | Form ,space and place. | 11 |
| 2.4.3 | Materials and texture. | 16 |
| 2.4.4 | Light and mood. | 18 |
| 2.4.5 | Presentation | 21 |

| No | Title | Page No |
|----------------------|---|---------|
| 2.5 | Introduction to malls. | 23 |
| 2.5.1 | Mall Definition | 23 |
| 2.5.2 | Functional requirements of malls. | 24 |
| 2.5.3 | Mall planning levels | 24 |
| 2.5.4 | Mall planning guidelines | 25 |
| 2.5.5 | Mall design guidelines | 26 |
| 2.6 | Interior architecture of malls | 31 |
| 2.7 | The previous studies | 32 |
| 2.7.1 | A study of key factor affecting customer relationship towards shopping mall. By Ajay Kumar 2014 | 32 |
| 2.7.2 | A scientific paper about shopping malls attractiveness a segmentation approach . By Mohammed Ismail El-Adly 2006 | 33 |
| 2.7.3 | Evolution of shopping malls: Recent trends and the question of regeneration . By Buket Eregun Kocaili 2010 | 33 |
| 2.7.4 | Working paper about Determinants of shopping behavior of urban consumers: By Rajagopal , PHD FRAS FIOMI SNI- II (MEXICO) .February 2009 | 34 |
| 2.7.5 | The Analysis Of The Previous Studies | 34 |
| 2.8 | Conclusion | 35 |
| Chapter three | | |
| Examples | | |
| 3.1 | Introduction | 37 |
| 3.2 | Example 1: Dubai Mall (UAE) | 37 |
| 3.2.1 | Introduction | 37 |
| 3.2.2 | Facts and Figures | 38 |
| 3.2.3 | Dubai mall design | 38 |
| 4.2.4 | What distinguishes The interior architecture in Dubai mall? | 43 |
| 3.3 | Example 2: Panorama Mall (KSA) | 48 |
| 3.3.1 | Introduction | 48 |
| 3.3.2 | Information about panorama mall | 50 |
| 3.3.3 | Panorama mall Project: Planning view | 51 |

| No | Title | Page No |
|---|--|----------------|
| 3.3.4 | Panorama mall Project: Designing view | 52 |
| 3.3.5 | What distinguishes the interior architecture in panorama mall? | 54 |
| 3.4 | Example 3: MyZeil Shopping Mall (Germany) | 58 |
| 3.4.1 | Introduction | 58 |
| 3.4.2 | Information about Myzeil shopping mall | 58 |
| 3.4.3 | Myzeil shopping mall design | 59 |
| 3.4.4 | What distinguishes the interior architecture in Myzeil shopping mall | 61 |
| Chapter Four Case Study (Afraa Mall) | | |
| 4.1 | Preview | 66 |
| 4.2 | Background | 66 |
| 4.3 | Khartoum city | 66 |
| 4.4 | Urban environment of Khartoum | 67 |
| 4.5 | Malls in Khartoum | 67 |
| 4.6 | Introduction to the case study (Afraa Mall) | 71 |
| 4.7 | Information about Afraa Mall | 71 |
| 4.8 | Project description | 72 |
| 4.8 | Floors Details | 73 |
| 4.10 | Structural design | 75 |
| 4.11 | Electrical and mechanical services | 75 |
| 4.12 | Finishing | 75 |
| 4.13 | Redesign of spaces | 78 |
| 4.14 | What Distinguished The Interior Architecture In Afraa Mall ? | 81 |
| 4.15 | Conclusion | 82 |
| Chapter Five Analysis And Discussion | | |
| 5.1 | Introduction | 85 |
| 5.2 | Sample of the study | 85 |
| 5.3 | Design of questionnaire sectors | 85 |
| 5.4 | The analysis of questionnaire results | 85 |

| No | Title | Page No |
|--|-------------------------------------|----------------|
| 5.5 | Conclusion | 97 |
| Chapter Six Conclusions And Recommendations | | |
| 6.1 | Introduction | 101 |
| 6.2 | Conclusions and results | 101 |
| 6.3 | Recommendations And Further Studies | 104 |
| References | | 109 |
| Appendix | | 113 |

List Of Figures

| No | Title | Page No |
|----------------------|--|----------------|
| Chapter Two | | |
| 2.1 | The orientation and how its effect inside the space | 8 |
| 2.2 | structural elements which have a significant visual and spatial effect on the internal environment | 9 |
| 2.3 | How services can be taken into account in the layout of the interior | 10 |
| 2.4 | Scale based on known objects | 12 |
| 2.5 | The difference between proportion and scale | 12 |
| 2.6 | The explanation of the word vista | 13 |
| 2.7 | The horizontal and vertical circulation through this shopping mall is key to the form and successful functioning of a large space. | 14 |
| 2.8 | Transient environments operate on the threshold between spaces | 15 |
| 2.9 | Window display | 19 |
| Chapter Three | | |
| 3.1 | External views (Dubai Mall) | 37 |
| 3.2 | Floors Plans (Dubai Mall) | 39 |
| 3.3 | Atrium space in Dubai Mall | 39 |
| 2.4 | Aquarium ,Water fall ,Atrium and ice rink (Dubai Mall) | 40 |
| 2.5 | Dubai Mall's aquarium | 41 |
| 2.6 | Accessible to the building(Dubai Mall) | 41 |
| 2.7 | Selection of materials (Dubai Mall) | 42 |
| 2.8 | Shops at Dubai mall | 43 |
| 2-9 | Linking between indoor and outdoor(Dubai Mall) | 43 |
| 2-10 | Selecting of materials which made the mall unique and attractive. | 44 |
| 2.11 | Vertical circulation(Dubai mall) | 44 |
| 2.12 | The Design of interior space(Dubai mall) | 45 |
| 2.13 | The huge waterfall (Dubai Mall) | 45 |
| 2.14 | Choosing of colors and materials(Dubai Mall) | 46 |
| 2.15 | Interior space and interface of shops(Dubai Mall) | 46 |

| No | Title | Page No |
|------|--|---------|
| 2.16 | Innovative of lighting(Dubai Mall) | 47 |
| 2.17 | Dubai Mall atriums | 47 |
| 2.18 | panorama mall view | 48 |
| 2.19 | Panorama mall view and location | 49 |
| 2.20 | Main lobby(panorama mall) | 49 |
| 2.21 | Panorama mall location | 50 |
| 2.22 | Al danube hypermarket & Jarir bookstore | 50 |
| 2.23 | Resturants,café and shops (panorama mall) | 51 |
| 2.24 | Connectivity to the site(panorama mall) | 51 |
| 2.25 | Profile of the building (panorama mall) | 52 |
| 2.26 | Vertical circulation (panorama mall) | 52 |
| 2.27 | External entrances for some shops | 53 |
| 2.28 | commercial, recreational and service areas (panorama mall) | 53 |
| 2.29 | Appearance of the structural elements inside the space | 54 |
| 2.30 | The density of the glass in the facades | 54 |
| 2.31 | Selected Features of materials and methods of it's implementation | 55 |
| 2.32 | Main lobby in panorama mall | 55 |
| 2.33 | The use of lighting in shops an corridors | 55 |
| 2.34 | Sky light of the atrium (panorama mall) | 56 |
| 2.35 | The transparency of materials in the interfaces | 56 |
| 2.36 | Using botanical elements inside the space | 57 |
| 2.37 | External views (Myzeil mall) | 58 |
| 2.38 | The location of Myzeil mall | 59 |
| 2.39 | The façade on the Zeil is sucked into a great void that makes us see the sky | 59 |
| 2.40 | The atrium of the mall | 60 |
| 2.41 | Transparent external shell is filtering the natural light | 60 |
| 2.42 | Vertical and horizontal circulation | 61 |

| No | Title | Page No |
|---------------------|---|----------------|
| 2.43 | Panels of glass and steel(Myzail mall) | 61 |
| 2.44 | The unique design with special concept | 62 |
| 2.45 | Using the structure of the building as main element in the distribution of the internal spaces | 62 |
| 2.46 | special solutions for the internal circulation | 63 |
| 2.47 | Artificial lighting(Myzeil mall) | 63 |
| 2.48 | Using organic forms such as shell internally | 64 |
| Chapter Four | | |
| 4.1 | The map of Khartoum state | 66 |
| 4.2 | Divisions of the Nile facades Project | 67 |
| 4.3 | Alwaha mall location | 68 |
| 4.4 | External views (Alwaha mall) | 68 |
| 4.5 | Outdoor features (Alwaha mall) | 69 |
| 4.6 | Internal views (city plaza mall) | 70 |
| 4.7 | Afraa mall location | 71 |
| 4.8 | Afraa mall project – Main Entrance | 72 |
| 4.9 | Components of basement floor(Afraa mall) | 73 |
| 4.10 | Components of ground floor(Afraa mall) | 74 |
| 4.11 | Components of first floor(Afraa mall) | 75 |
| 4.12 | Main elevation finishing(Afraa mall) | 76 |
| 4.13 | Internal finishing(Afraa mall) | 76 |
| 4.14 | Pray area finishing –roller vinyl(Afraa mall) | 77 |
| 4.15 | Wood partition in bazaar area(Afraa mall) | 77 |
| 4.16 | Frameless glass partition (Afraa mall) | 77 |
| 4.17 | Gypsum boards (dry wall) and aluminum suspended ceiling (Afraa mall) | 78 |
| 4.18 | Outdoor features and facade from first to recent design (Afraa mall) | 79 |
| 4.19 | Basement parking replaced to be administration office ,recreational and entertaining areasand stores (Afraa mall) | 79 |
| 4.20 | some rearrangements in the ground floor (Afraa mall) | 79 |
| 4.21 | Eliminate using of colors and painting in the domes and kids play areas (Afraa mall) | 80 |
| 4.22 | Redesign of the main entrance(Afraa mall) | 80 |

| No | Title | Page No |
|---------------------|---|----------------|
| 4.23 | External circulation (car parking)(Afraa mall) | 81 |
| 4.24 | The design of main elevation façade with the use of various materials (Afraa mall) | 81 |
| 4.25 | Vertical circulation elements (Afraa mall) | 82 |
| 4.26 | structural elements as apart of interior design concept (Afraa mall) | 82 |
| Chapter Five | | |
| 5.1 | Educational degree | 86 |
| 5.2 | Years of experience | 86 |
| 5.3 | Nature of work | 87 |
| 5.4 | Work sector | 87 |
| 5.5 | The size of corporation or institution | 88 |
| 5.6 | The concept of interior architecture became more useable and well known | 89 |
| 5.7 | A considerable awareness of the concept of interior architecture . | 89 |
| 5.8 | The compatible between the study that it had been received and the concept of the interior architecture | 90 |
| 5.9 | Understanding the fundamentals of interior architecture from designing stage. | 91 |
| 5.10 | The important of knowing the fundamentals of interior architecture | 91 |
| 5.11 | using the fundamentals of interior architecture in the design | 92 |
| 5.12 | limitation of interior architecture | 92 |
| 5.13 | Separate the interior architecture from structural system | 93 |
| 5.14 | The interior architecture as an independent specialization | 93 |
| 5.15 | Attending courses or lectures which related to the interior architecture | 94 |
| 5.16 | The understanding of the community and it's requirements and behaviors | 94 |

| No | Title | Page No |
|-----------|---|----------------|
| 5.17 | The optimum design of the mall reflects the urban nature of the country | 95 |
| 5.18 | The detail study of requirements of malls helps in taking a right decision in designing the internal spaces | 95 |
| 5.19 | the right selection of colors, lighting and textures as an important factors to attract users. | 96 |
| 5.20 | Introducing a amusement factors and adding attractive elements in corridors give a sense of comfort and lack of boredom | 96 |
| 5.21 | The relation between selection of materials and lighting of the shops and the whole idea of the mall's design | 97 |

List Of Tables

| No | Title | Page No |
|-----|---------------------------------------|---------|
| 2.1 | shopping center classification in U.S | 25 |

Definition Of Terms

| Term | Definition |
|----------------------------|---|
| <i>tender documents</i> | Documents setting out the extent and qualities of project, provided to companies in order that they may quote prices and terms for undertaking the work. |
| <i>quotations</i> | A quotation is the offer by a supplier or contractor to undertake specified work to defined standards for a fixed price. It should not confused with an estimate, which sets an approximate cost. |
| <i>approvals</i> | All building work is subject to rules and laws governing safety, amenity and integrity. Local authorities are responsible for ensuring compliance with these rules and laws, and their approval should be sought before embarking on changes. Changes to the use, size or appearance of the building require Planning Permission Approval. Structural, thermal, access, fire safety, drainage and hygiene standards are defined by the Building Regulations, and the designee is required to show that . this standards have been met by applying for Building Regulation Approval. |
| <i>planning supervisor</i> | . All commercial activity must accord with Health and Safety Regulations. Building sites are potentially dangerous places and the designer, contractors and personnel all have a responsibility for ensuring that the regulations are met. Commercial work tha exceeds 30 man-days in work and/or more than 500 man-hours falls under Construction Design Management Regulations and will be overseen by a planning supervisor responsible for health and safety. |

| | |
|--|---|
| <i>The Modulor</i> | Devised by Le Corbusier and patented by him, the Modulor was the subject of his 1948 book, <i>Le Modulor</i> . Intended to be a harmonious scale applicable to architecture and engineering, I has seen widespread use in all aspects of the design industry. It uses the main proportions and dimensions of the human body in conjunction with the Golden Section, Fibonacci Sequence and a ratio of spatial distances to devise a system of measurements to be used when designing buildings and their interiors. |
| <i>vista</i> | a term borrowed from the vocabulary of the landscape designer, are devices often used to frame or extend the outlook from key viewpoints of grand houses and their grounds |
| <i>architraves</i> | The element, often a timber moulding, that masks the joint between the door or window frame and an adjacent wall surface. In traditional construction the first being made of timber, the second of plaster, there will always be a crack between these surfaces– a crack accentuated by the slamming of the door or window. With careful detail design and choice of material it is possible to minimize or eliminate this component. |
| <i>skirtings</i> | The cover strip that runs at the bottom of the wall an abuts the floor. As with the architrave this is a device for reconciling two dissimilar materials. It also provides a tough surface intended to resist the impact of floor cleaning and furniture legs. |
| <i>orthographic drawings</i> | A set of drawing conventions in which any sense of perspective is eliminated, as if the building is viewed from an infinite distance |
| <i>three-dimensional computer model</i> | A three-dimensional representation of geometric data, stored and generate by a computer. |
| <i>rendering</i> | Rendering software uses color and lighting to represent the intended reality of a building using a computer model or image from a computer model. Depending on the quality of the software and computer, and the needs and proficiency of the user, it is possible to create images that are indistinguishable from reality. |

| | |
|-----------------------|--|
| <i>texture-map</i> | Software that applies pattern and texture to the surfaces of a computer model in order to represent real life materials. |
| <i>ICSC</i> | <i>International Council of Shopping Centers</i> |
| <i>display</i> | When working with clients in the retail sector, the interior architect's job, essentially, is to provide a space in which the client's product and brand will be displayed in an appropriate and effective manner. |
| <i>brand values</i> | All commercial organisations are focused on building and maintaining their business by identifying their target customer and ensuring that the company and the product are perceived as matching the personal standards and aspirations of the customer. |
| <i>Ergonomics</i> | The study of the body's response to physical and physiological loads and strains. It is concerned with such things as safe weight limits, the effects of repetition, the application of force and the effects of posture. |
| <i>anthropometric</i> | The measurement of humans'. Statistical data about the distribution of body dimensions in the population used to optimise human interaction design decisions. |