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ORTHOSIS HOUSE: A HABITABILITY STRATEGY FOR *AGEING IN PLACE*

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Abstract: Choosing "Ageing in place" refers to the individual's ability to remain living in the same environment without the need to move as a result of ageing. A prerequisite for aging in place is to detect the physiological-functional and socio-economic demands of the user and from there propose constructive and assistive technologies in order to make human interaction with the built environment as responsive as possible. Considering the home as an orthosis for the ageing process, based on habitability strategies, can, through equity of use, safety, comfort and privacy, promote physiological-functional abilities for an abundant life in senescence and senility. This article presents the opportunities of gerontechnology applied to the concept of the home-orthosis as habitability strategies, with the figure of the architect as a potential agent of transformation together with the multidisciplinary team of integrated health care for the elderly for ageing in place (AiP).
Keywords: Ageing in place (AiP), Gerontechnology, Architecture, Human Building Interaction (HBI)

Several European countries have been working on the proposal to create housing strategies that promote *ageing in place,* as a way of reducing the cost of institutionalization and hospitalization, as well as the opportunity to promote active ageing. Following the changes that have taken place in the field of housing and the decentralization of care through the General Exceptional Medical Expenses Act in the Netherlands, these public policies have given a leading role to housing as a place of care in promoting the complex and challenging concept of ageing in place. The complexity lies in the difficulty of defining replicable and financially accessible strategies for users, the health and housing system, since there is no one-size-fits-all model and AiP involves factors beyond housing (HENEGOUWEN, 2019).

Such public policies aimed at creating responsive environments for the elderly have been encouraged not only in Europe, but throughout the world, in which a growing number of cities and communities, local authorities and regional governments are participating. The WHO, through publications, contributes a compilation of data, which through information systems, provides us with indicators, which enable monitoring and evaluation for the success and sustainability of age-friendly policy initiatives. It also defines potential sources for drawing up a comprehensive picture of the situation of older people and their quality of life, and considers how to communicate this effectively. Always based on lessons learned from age-friendly initiatives and adapted measurement, monitoring and communication tools, such as healthy ageing profiles and community information systems. Considering participatory approaches to community assessment with older people and bottom-up initiatives in information gathering and sharing, which support older people to remain active and involved in their communities and thus continue to do the things that are important to them (WHO, 2018).

As well as making it possible to cope better with chronic illnesses and reduce the risk of accidents in the residential environment, a greater understanding of the impacts of the physiology of ageing allows us to define strategies for assertive and user-responsive habitability interventions. These guidelines range from the architectural design phase to excellent usability in terms of safety, comfort, privacy and equity of use. The following diagram elucidates the structure proposed within the concept of the Orthosis House in the promotion of AiP.

The concept of housing that is responsive to the needs of the elderly has resulted in new guidelines and standards for architectural design, based on a concept that is gaining more and more interest, which is "lifetime housing". It refers to the adaptability of a home environ-

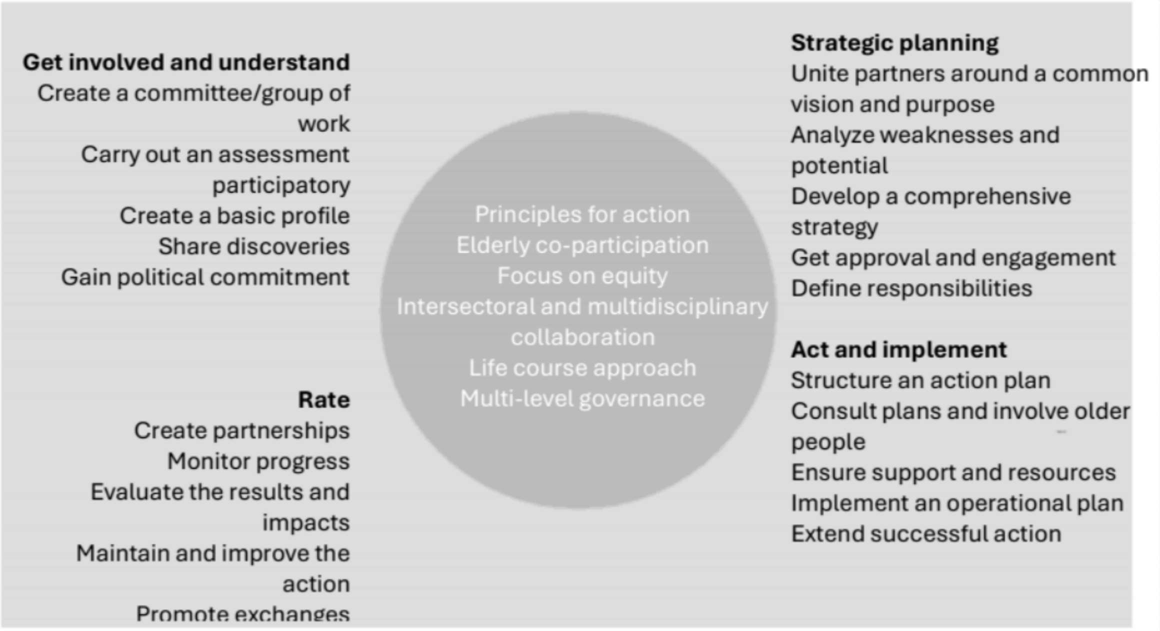

Diagram 01: Model of principles and steps for creating elderly-friendly environments

Source: (WHO, 2018)

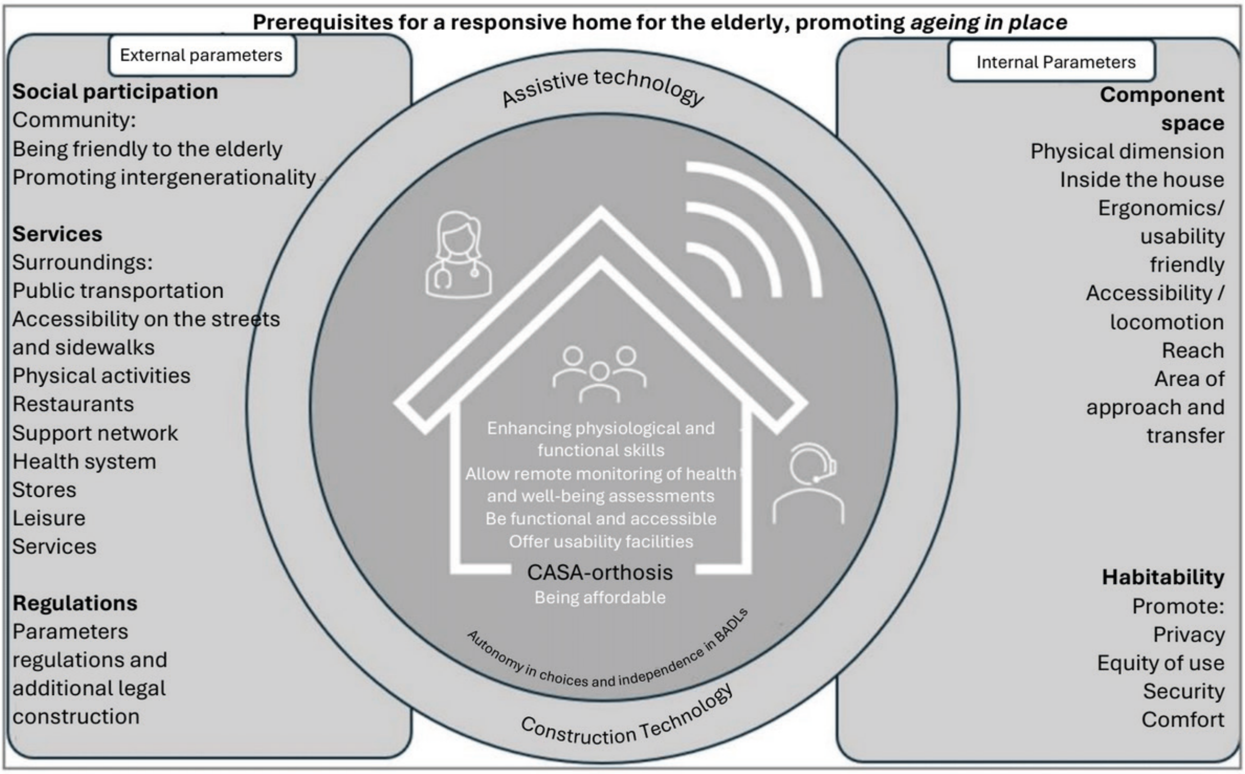

Diagram 02: Home-orthosis: HBI-related conditioning factors that promote AiP

Source: Prepared by the author

ment's ability to reconfigure itself to the changing needs of individuals throughout their life cycle. This encompasses a broader interpretation of physiological-functional demands and the suitability of housing. Recent studies direct us towards aging-in-place strategies, which include optimizing function by manipulating the design of the home, furniture and fittings, and reducing isolation, with the help of the social network/support as well as technology, as shown in the table below:

There are several strategies to consider when living with ageing, as shown in the table below:

THEORETICAL BACKGROUND

The history of architecture shows us a close affinity and relationship with the human body, which plays a key role and is recognized in different discourses, paths and ideas. This is particularly evident in Western architecture and culture, in which the idea of the body has been defined through different contexts. Plato defined the human body not as a single entity, but as a conglomeration of (material) body, mind and soul, operating under its own discretion and logic. One concept that influenced architecture the Roman Marcus Vitruvius Pollio, who, through his texts on the body, assumed it to be the main generator of spatial order in architectural theory. Vitruvius argued that various properties of architecture could confer therapeutic qualities on its environments, which were a medicinal instrument for enhancing the health and well-being of users and convalescence. Based on this assumption, he defined strategies for implementing and designing buildings to optimize light and health conditions (REGO, 2012).

Architecture, as a science, deals with the manipulation of the physical environment to facilitate certain functions and provoke the desired behavior. This environment is mainly made up of spatial elements, sensory elements in terms of textures, colors, patterns, acoustics, lighting, etc. It is therefore possible to argue that the human body, either through the adoption of the human scale or subjectively, in terms of the conceptual idea of spatiality, can be seen over time as the predominant regulator within architecture and key driver of design. In the 17th century, René Descartes, the father of modern philosophy, distinguished things as subjects and objects, in which the subject is the one who perceives and observes the object, and is therefore capable of thinking, having mastery over space and thus facilitating its organization in space and time. The object is, reciprocally, the thing being observed. In order to position the body as a key subject in architecture, the human body must first be defined. However, in order to define the body, it is necessary to assume how the body will operate the space (AZIZI, 2020).

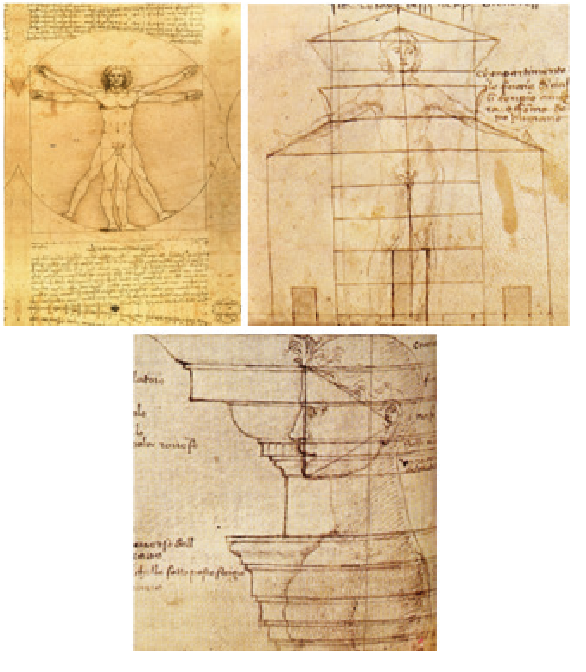

Figure 02: The Vitruvian Man - Treatise on Architecture (1490)
Source: Leonardo da Vinci - Google 2024

Le Corbusier's modular man, seen as another reference used to predict the design of buildings, through the proportions of an "ideal body", which related to the elements of buildings.

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Domain	Description
Accessible and inclusive design	A responsive, elderly-friendly home is accessible and functional for everyone
Measuring and monitoring health and well-being	When necessary, the house measures, monitors and evaluates the physical and mental constitution of its inhabitants, including behaviors in order to obtain knowledge, i.e. the data needed to take responsive action.
Carry out interconnectivity actions	Based on the results obtained from measuring, monitoring and evaluating, the house is able to offer usability solutions that enhance physiological-functional abilities.
Offer usability facilities	A home-orthosis can offer facilities and entertainment, as well as allow communication with the multidisciplinary team for continued and assisted care, support network, family, neighbors and friends

Table 01: Attributes for a responsive and home

Source: (HENEGOUWEN, 2019)

Strategies for senior housing models		
Fixed structure	**Categories**	
Residential object	Independent living	Residential unit
	Private area Common area	
	Living area Circulation area Approach area Reach and ease of use Number of rooms Private toilet Toilet for common use Square footage Light comfort Visual comfort (permeability) Biophilic comfort Thermal comfort Acoustic comfort Usability comfort (fairness of use and ergonomics) Air renewal comfort Intuitive signposting and guidance Comfort of materials (colors and textures)	
Flexible structure	**Care support network**	
	Formal ($)	Informal
	24-hour caretaker and care team	Relative and friend and/or household
	24-hour emergency team	
	Non-intrusive health monitoring	
	On-site nursing facility	
	Services	
	Cleaning and maintenance service	
	Continued and assisted care service	
	Laundry service	
	Pedicure and manicure	
	Hairdresser and barber	
	Reception and concierge	
	Technical service	
	Nutrition and dietetic assistance service	
Socialization	Common area for recreational activities: cooking, coffee, bingo, dance, gymnastics, soiree, music therapy, games, crafts and handicrafts	

Spatial component	Location, accessibility of connectivity to public transport and basic services, location within the community
	Configuration: single dwelling unit or conglomerate
Technology	Smart home (Building and Assistive Technology)
	Home automation
	Robotic care (telehealth and telemedicine)
	Motion and activity sensor
	Presence sensor
	CO2 sensor, gas leak, water, security system and alarm
	Connectivity with support network
	Energy efficiency rating
Specific building regulations (taxes, tax incentives, rules and laws)	*Senior*
	Active communities or senior apartments
	Detached house with individual or shared facilities
	Single or shared assisted living
	Infirmary or day hospital
	Transition hospital
	Day center
	Continuing care community
	ILPI - Long-stay institution for the elderly
	Republic for the elderly
	Co-housing
	Clinics and *memory care* (supportive care for BADLs)
Types of facilities	Formal and/or informal care service
	Cleaning the house
	BADL (basic activities of daily living) and IADL (instrumental activities of daily living) services
	Health care and rehabilitation
	Nutrition and dietetic services
	Escort services and shopping support
	Transportation service
Admission requirements and classification	Functional clinical profile of the elderly (robust/dependent elderly I,II, III)
	Minimum and maximum age
	Vulnerability and dependence in BADLs and IADLs
	Socio-cultural profile and individual preferences
	Marital status
	Socio-economic profile
Contract	Delimitation of the attributes and demands to be offered
Suppliers	Constructive and assistive objects
	Services, care, social integration, BADL support
Tenure status	Rent/ lease/ pay per use/ Time sharing
	Social housing
	Sole proprietor / shared

Table 02: Strategies for senior housing models

Source: Prepared by the author

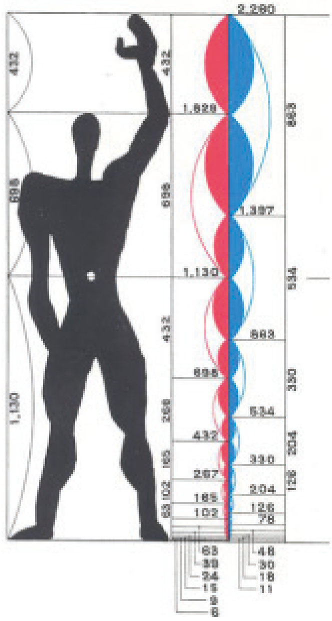


Figure 03: Le 's modular man

Source: (AZIZI, 2020)

We are born naked and with insufficient armor, so we need means to complement our natural abilities, since nature is indifferent, inhuman (extra-human) and inclement, according to Corbusier. For him, modern architecture is the space of the artificial, capable of supplying these human deficiencies. Shifted from the artificial to the artificial, would architecture, from the perspective of modernist thinking, be a prosthesis that takes on a technological extension of the body, which is neither natural nor cultural? From this point of view, Diogenes' barrel would be a remarkable improvement on our natural protective organs (our skin and scalp), taking over the primordial cell of the house. What can we say about the current use of files and copies, which remedy the inadequacies of our memory; closets and sideboards, which serve as containers in which we store the "auxiliary limbs" that protect us from cold or heat, hunger or thirst. And by considering the mechanical system that surrounds us as an extension of our limbs; elements that actually take on the function of artificial limbs (MARK WIGLEY, 1991).

This vision of interpreting buildings as "objects of human limbs", worn like clothes, and mechanized furniture as an extension of the body, fully identifies with the precepts of modern architecture. Thus, the classic relationship between structure and ornament, hitherto understood as that between a body and its clothes, was shifted to the body in relation to the building. Traditional ornamentation seems to be removed from the building, when the building itself becomes a kind of ornament, worn by its occupant. But this mechanized ornament is structural, restructuring the body that wears it. Prosthetic architecture becomes a substitute body "intended to support the person as such"; which reminds us of Freud's assertion, in "Malaise of Civilization", that, like other technologies of communication and perception - the airplane, the telescope, the camera, the telephone and writing - housing is a prosthetic extension, an "auxiliary organ", used as a substitute for the woman's body, "the first dwelling". In other words, the building is the prosthetic substitute for a body already occupied, in fantasy, as a building. The categories of body, prosthesis and architecture are mixed together, and Freud's questioning when he assumes his own body is a prosthesis of consciousness, in which, despite everything, it is a piece of external reality like any other, which can be identified by him with the help of his sense organs from outside himself, and is therefore a prosthetic accessory, used as a kind of "garment" like any other. In a strange way, the body depends on the foreign elements that transform it, which are reconstituted and supported by the "supporting limbs" in order to extend it and from there, there is the concept of prosthesis linked to the architectural discourse (MARK WIGLEY, 1991).

Always considering the aspect of human demands and abilities, in order to understand the effects of mechanization on the human being, based on discerning to what extent mechanization corresponds to and to what extent it contradicts the unalterable laws of human nature, Siegfried (1970) presents us with important arguments about the construction of civilization through the modest things of daily life that accumulate throughout history. Be it through humble objects that have shaken our way of life to its very roots, accumulating forces that act on anyone throughout the process of civilization. Tools and objects that make everyday life easier for us are of equal importance to explosions of history; after all, it is in anonymous life that particles of continuous improvement accumulate in quantum leaps. These objects, or external forces that help us on a daily basis, have their inventive origin based on a specific attitude, without which they would never have arisen, whose motivation is the orientation of that period, driven by external impulses in order to bring a solution to that particular problem. For a historian or scientist, nothing can be trivialized, because nothing can be taken for granted. They have to see objects not as they appear in the context of everyday use, but as the inventor saw them when they took shape. To do this, it is of the utmost importance to detach oneself from contemporary eyes and transport oneself to the context of the time and space in which it was built. From there, it is possible to assess the impact of the before and after in order to establish its meaning. Thus, the writing of history is always linked to the fragment of facts that are presented in a dispersed way (GIEDION, 1970).

The increase in efficiency in coal mining implemented by Frederick W. Taylor due to a careful analysis of each of the workers' movements and carried out by means of continuous improvement techniques, today known as Kaizen; or even when Frank B. Gilbreth increased the efficiency of masonry by reducing slope and by rationally rearranging tools, American housewives began to question the efficiency of their own work environment. Gilbreth increased the efficiency of masonry by reducing slope and by rationally rearranging tools, American housewives questioned the efficiency of their own work environment and began to observe their movements, counting their steps as they went about their daily routine. It was known that a home could not be run like a factory; but it was also clear that the only way to escape exhausting work was through precise analysis. The initial breakthrough was already in the air and the wives of these inventive gentlemen began to wonder how they could improve the efficiency of their housework. In 1909, they came up with the plan for a small house specially designed to save steps in housework. In the fall of 1912, Christine Frederick, one of the first women to concern herself with "bringing the science of efficiency into the home, published her series entitled "The New House-keeping" in the Ladies Home Journal. An informal conversation with her husband made her think about how much time is wasted in poorly organized kitchens and a whole universe of inventiveness responsive to the residential environment took place, proving that it is in the perceptions of daily life that small advances become great achievements for the well-being of society (GIEDION, 1970).

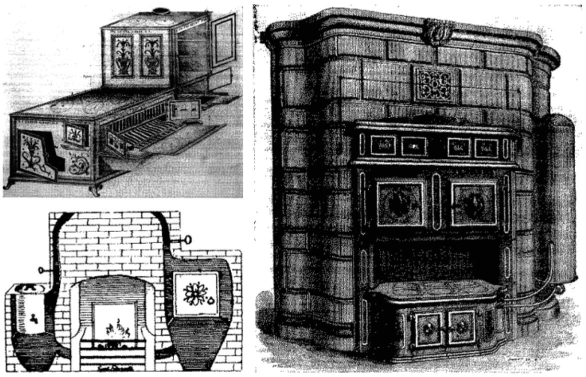
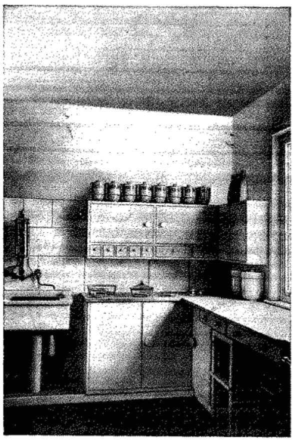
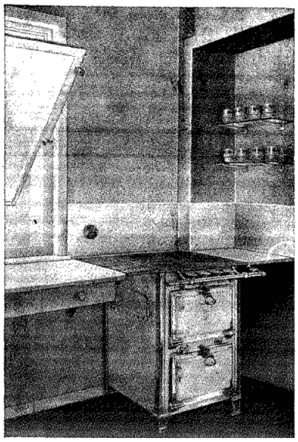
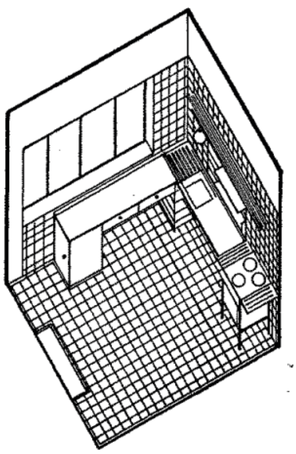
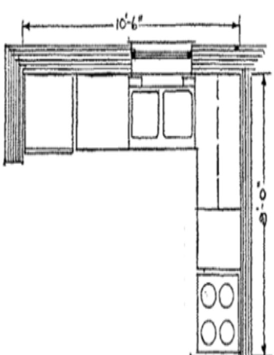
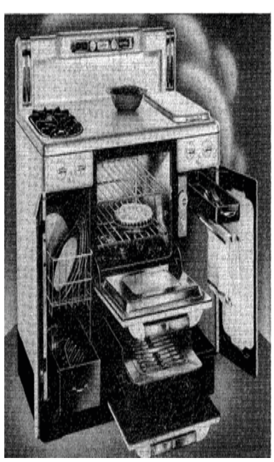


Figure 04: The evolution of the stove -1848 - the advent of coal gas made it possible to concentrate the heat source, which was then confined to a burner. The 1806 / 1871 boiler fireplace also took on an important role, especially in cold countries, bringing greater comfort.

Source: (GIEDION, 1970)

 	Pantry cabinets (1891) and standardized kitchens (1942) sold through catalogs that applied the principles developed by Catherine Beecher, whose slogan read: "everything at your fingertips, with cabinets organized logically, without clutter, and the flexibility to add new modules.
 	Continuous work surfaces - Kitchen at Haus am Horn, Bauhaus, Weimar, 1923. One of the first kitchens designed by the architect as an integrated unit within the modern house. On the long wall there is a simple kitchen sink and a sideboard separated into a base cabinet and a wall cabinet. The large work surface below the bay window is continued by the gas cooktop, which is in turn extended by a work surface. The work surfaces total those of a kitchen two or three times larger. The fully utilized window area is reminiscent of the American Craftsman kitchens adopted around 1910.
	Continuous work surfaces: J.J. P. Oud, L-shaped kitchen, Weissenhof settlement, Stuttgart, 1927, the L-shaped kitchen of terraced houses in the experimental workers' settlement, although this low-cost kitchen seems to have little in common with the mechanized and enamelled kitchen of 1940, its organization incorporated almost everything that manufacturers would later offer in luxurious versions.
 	L-shaped mechanized American kitchen, 1942 Continuous storage, preparation, cleaning and cooking area centers.

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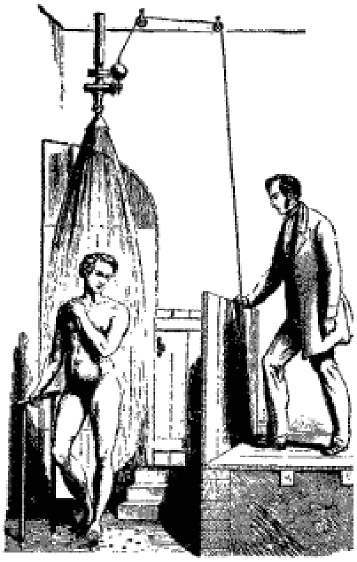
	Advent of the electric stove, 1942, with automatic time regulation and heat gradation.
	The mechanization of bathing, the advent of pipes and industrial engines being adapted to the daily routine of the inhabitants.

Figure 06: Evolutionary process of residential mechanization

Source: (GIEDION, 1970)

Figure 05: Smart stove, with the promise of being able to be controlled remotely by the user, via cell phone and tablet, with the help of a Home connect type application, via the internet.

Source: Google 2024

The road to today's layouts, whether in kitchens, living rooms, bedrooms or bathrooms, has been long and often arduous. The dependence on parallel technologies for the development of an advance that today is seen as simple, at the time was seen as a major hindrance or even impediment, which slowed down the evolutionary process. Today, the challenge of new and challenging technologies such as Artificial Intelligence is present. What to expect, how and how far can we go with so many attributes? And what about privacy? How can we think about and prepare for such a revolution in an ageing society? What are the advantages and dangers of this new phase of life that society is entering?

Below you can follow the evolutionary process within what can be called contemporary cuisine.

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The process of mechanization of the residential environment has brought challenges to the usability of environments in a flexible way and the maximum use of the freedom of a floor plan, by concentrating all the installations at one point. It is important to note that installation costs account for around 40% of construction costs. The proposal to locate bathrooms, kitchen, laundry, heating and all the wiring in a concentrated way, which he called the mechanical core, reduced costs and allowed everything to be prepared in a factory and pre-assembled before being taken to the building site. This revolutionary system was conceived and developed in 1927.

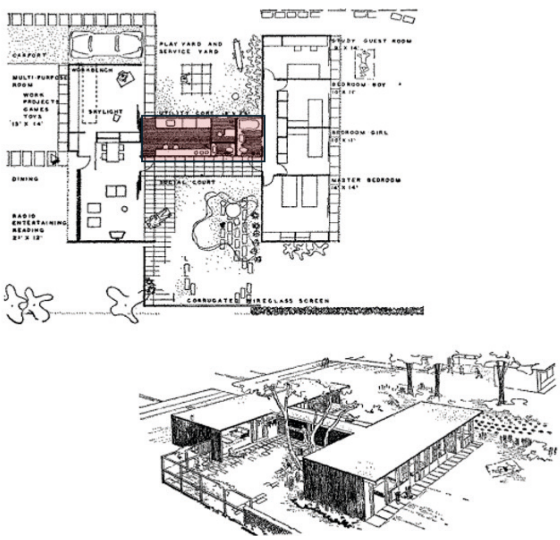

Figure 07: The Mechanical Core: H-shaped house by J. and N. Fletcher, 1945. In a competition for a small house for the average family, a design built around a mechanical core won first prize. Its shape connects the intimate bedroom area and the living room, a symptom of its dominant influence at the time.

Source: (MARK WIGLEY, 1991, p. 626)

The evolution of the bathroom from a nomadic condition to a stable one occurred instantaneously, simultaneously with the arrival of running water and sewers. Before that, it would have been pointless to dedicate a room exclusively to bathing. With its structure came new challenges, such as: "How important should the bathroom be in the house? How does it relate to the other rooms? What do you want in terms of size, layout and arrangement? Do we want to shower in a spacious, comfortable and safe room or in the smallest space possible?

The choice between the bathroom as a room among other rooms or the bathroom as a cell large enough to house accessories does not depend solely on economic means. It corresponds to two stages of development, the first of which we can call English, whose space demanded spaciousness, without a strict layout and reflected the status of its owner, and the adornment of the furniture carried over to the bathroom accessories. The second, along American lines of functional and servile usability.

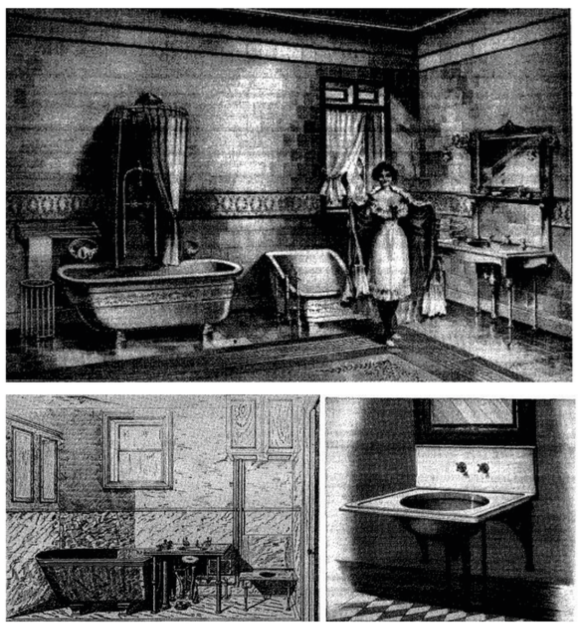

Figure 08: Bathrooms - English and American by George Vanderbilt, NY (1885)

Source: (MARK WIGLEY, 1991, p. 686)

In 1908, in the USA, the first hotel to offer a room with a private bathroom was the Statler Company, with around two thirds of the 300 rooms and designed by Ellsworth M. Statler, whose immediate success allowed it to expand.

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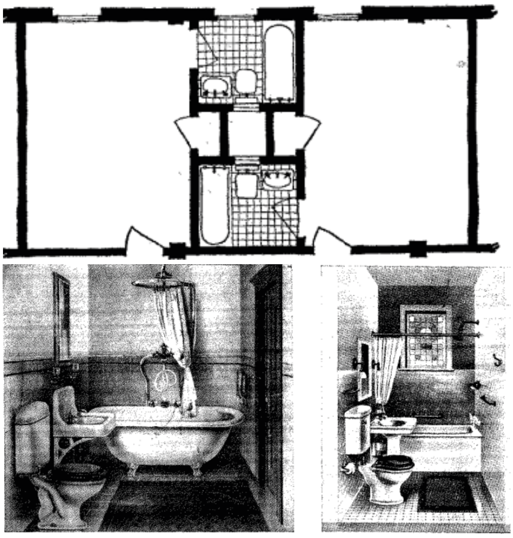

Figure 09: Hotel Statler Company (1908) USA
Source: (MARK WIGLEY, 1991, p. 699)

Still within the evolving scenario of habitability, in 1869, Catherine Beecher presented a floor plan of a city apartment with built-in cupboards, a compact kitchen and a bathroom, thus anticipating not only today's kitchen but also the compact, utilitarian kitchen.

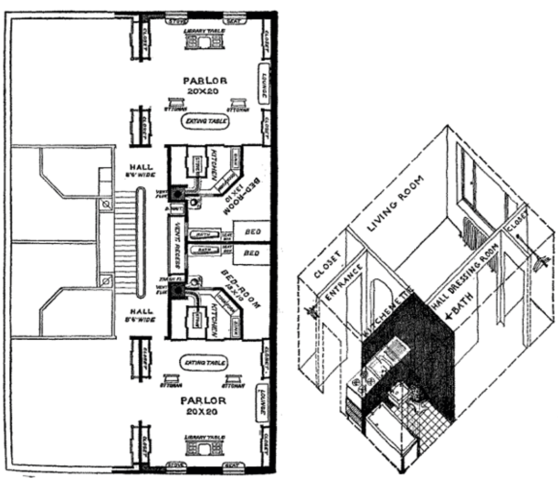

Figure 10: Floor plan of a city apartment
Source: (MARK WIGLEY, 1991, p. 696)

Considering the evolutionary fragments of the anonymous history of our period, new interrelationships and complex meanings emerge about the process of mechanization and usability. Since everything depends on its usability. The question therefore arises, "What does mechanization mean to man?". He is an agent, like water, fire and light. It is blind and has no direction of its own. It must be channeled. Like the powers of nature, mechanization depends on man's ability to make use of it and protect himself against its inherent dangers. As mechanization arose entirely from the mind of man, it is more dangerous to him. Being less easily controlled than natural forces, mechanization reacts to the senses and mind of its creator. Controlling it requires an unprecedented superiority over the instruments of production. It requires everything to be subordinated to human needs. It is a constraint that involves multiple agents, from the point of view of the user as well as the way it is manufactured and maintained. As a result, the individual creates an interdependence with the new facilities and technologies, and relationships are much more complex and interconnected than in any previous society. This is one of the reasons why man today is dominated by the media that surround him (MARK WIGLEY, 1991, p. 714).

ARCHITECT OF CHOICE IN PROMOTING RESPONSIVE ARCHITECTURE

The term architect of choice refers to the person who is responsible for defining a context that allows people to make choices, and in the context of the real world there are many people who take on this role without realizing it. Whether it's through a prescription, in which the doctor is responsible for choosing the one that best meets the patient's needs. Whether it's the employee who prepares a data collection form, or even the parents' guidelines for raising their children, everyone is doing the work of choice architecture. There are many parallels between choice architecture and the traditional way of practicing architecture. However, neither can be seen as neutral. Whether designing a new building or even a proposed renovation or retrofit, the architect is subject to a series of regulations and technical, spatial and user and stakeholder requirements in the briefing to define the program of needs (THALER; SUNSTEIN, 2021, p. 17).

In the architectural design process, in practical terms, the built environment includes doors, windows, circulation areas, lighting, circulation corridors and technologies, as well as access, the building's position in relation to the sun, views, prevailing winds, security, layout, ergonomics, maintenance and execution. All these factors influence the interaction between the people who use the building. A wrong choice, even if seemingly small, can have a big impact on people's behavior. Therefore, it should be assumed that everything is important, since these details often take the lead in guiding the user's attention and performance in a particular direction. Considering every detail as important can sound paralyzing, but good architects know that it is impossible to design a perfect building, but assertive choices can and should be made in order to make the final product the most beneficial. The architect of choice has the legitimacy to influence people's behavior in order to prolong lives and make them as healthy and better as possible. To this end, we advocate conscious efforts by various actors, from private sector institutions to government, to influence users to make assertive choices, as a way of making choices that favor an easier and better life (THALER; SUNSTEIN, 2021, p. 18).

Research in the social sciences shows that, for the most part, people make wrong decisions, decisions they wouldn't make if they had been paying attention, if they had all the information and self-control, or if they had full cognitive capacity. Intervention through libertarian paternalism is innocuous, white and non-intrusive, precisely because it doesn't limit or overburden users. The architects of choice strategically and consciously try to guide them towards improving and stimulating lives. Changing behaviors in a predictable way, without prohibiting choices or significantly altering the budget. It's an easy intervention, through intuitive and useful stimuli that can be avoided, brings quality of life, assertiveness in choices without curbing other desires. The architect's clarity of choice broadens users' horizons, bringing profiled, flexible, non-imposing options, but capable of being responsive to the user for a life of abundance. Choices depend in part on how the problem is presented, so it's vitally important that the facts are perfectly framed and that people are open to stimuli. Older people underestimate the risk of an accident, or even of contracting a serious disabling illness over time. This unrealistic optimism is a common characteristic of humans in any social class and the fact that they underestimate potential weaknesses and threatening situations makes them negligent, without taking proper care of preventive measures. If they are aware of the risks and unrealistic optimism, these can serve as stimuli. When warned or forewarned, they tend to be less optimistic and negligent (THALER; SUNSTEIN, 2021, p. 26, 55).

Considering the built environment as a therapeutic and supportive space for the losses of senescence, within the residential environment, in order to make the aging process comfortable is a challenge. It is necessary to be fully aware of the role of architecture from the outset so that the result is a therapeutic environment that preserves and enhances life, taking into account the reduction of stress and fatigue in the user's interaction with the environment, whether through constructive or assistive technology.

Considering the current context of new technologies that support the preferences of users aged 55 and over within the sociodemographic profile of population aging, a new field of housing models for aging in place has emerged, granting a certain degree of freedom, independence in activities of daily living, security and privacy to the elderly. Although the market is still positioning itself with real estate offers that are disconnected from the real de-

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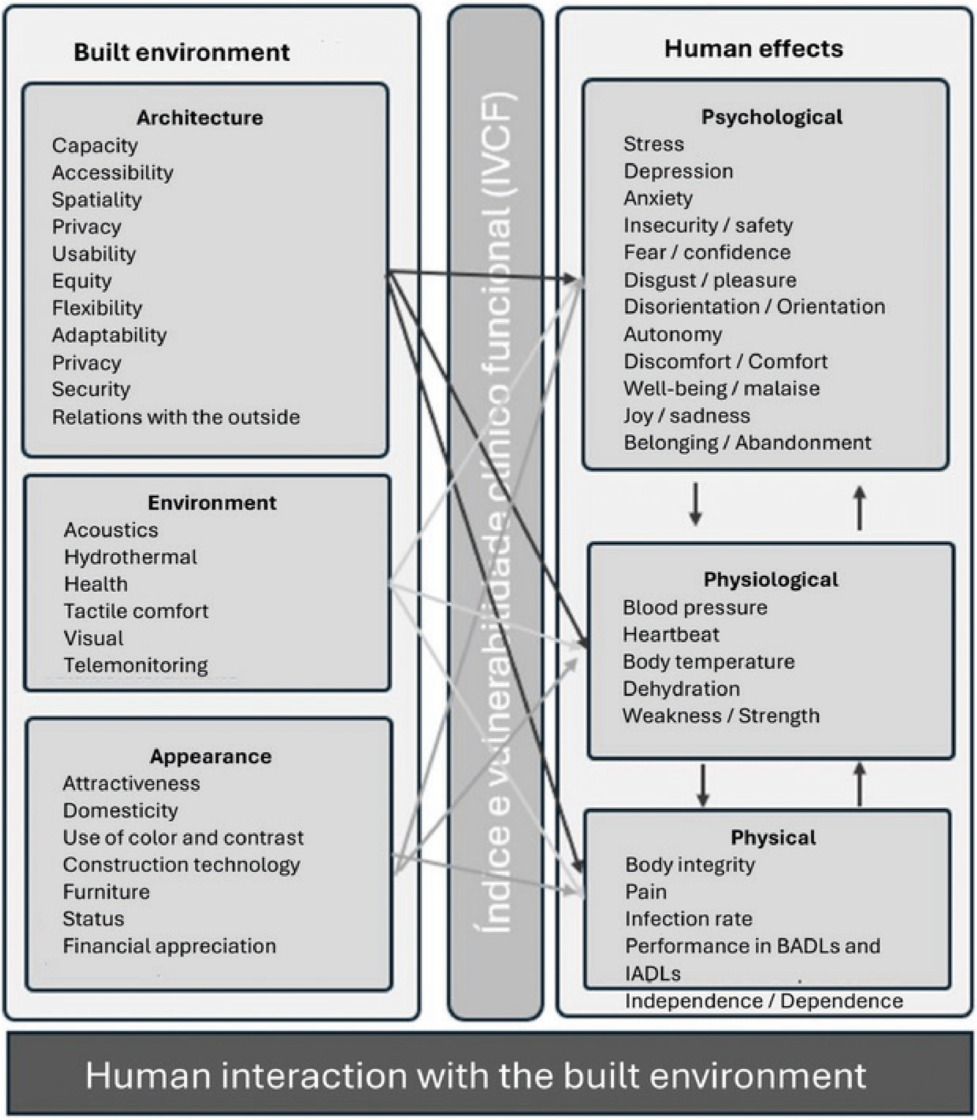

Figure 11: Home-orthosis conceptual matrix

Source: Prepared by the author

mands of users, imposing them in a way that is detrimental in the long term. Therefore, the stakeholders involved in developing and realizing housing models for aging *in place* should always consider the user's wishes, with affordability and the user's clinical-functional profile as a premise in real estate alternatives, which in a responsive way collaborate with demands for *aging in place*.

Users' unfamiliarity with these new habitability models, always considering human interaction with the built environment, based on the perception of the physiological-functional vulnerability index and the imminent risks imposed by the environment on the user in the performance of BADLs, make it difficult to engage in co-participation. In addition to the dissociation between stakeholders, from the user to the support network and long-term care, which often differ from the vision of developers and builders, who always strive for maximum profit, right from the conception of the project. A risk factor for the user in the residential environment is neglecting the environmental risks of the home in the aging process (HENEGOUWEN, 2019).

ORTHOSIS AS A CONCEPT FOR A HOUSE

Orthotics are external devices designed to correct and improve the function of the body and are used to treat problems generally resulting from injuries, illnesses, congenital defects or the ageing process. They are indicated to enhance the individual's abilities by controlling motor skills, which through immobilization makes it possible to assist movement and limit undesirable movements, as well as reducing the force and wear and tear involved in weight bearing. It is also used to prevent the onset of deformities and pain-generating stressors. It should be simple, comfortable and as discreet as possible. When choosing materials for the production of orthoses, the forces to which they will be subjected, durability, weight, flexibility and ease of use must be taken into account. Orthoses work according to the basic laws of physics and incorporate forces, resistances, axes of rotation and moment amplitude into their operation. Anatomical, physiological, kinesiological, biomechanical and pathological characteristics affect the choice of materials and technologies to be used, as well as a thorough understanding of rehabilitation protocols. For this reason, in services that provide assistance to people with disabilities and the elderly, this action is commonly carried out by occupational therapists (MS, 2014, p. 190)

The design and execution of the orthosis must meet and be in accordance with the person's needs, in order to support and protect, to enhance the process of re-establishing skills in order to facilitate and enhance the performance of functionality. With an ostensible demand for preserving the physiological-functional state of the tissues and thus preventing deformities and injuries, guaranteeing independence of movement; in order to allow a balanced function of the unaffected muscles. In addition to promoting, where possible, functional grip patterns and mobility, stability; guaranteeing the preservation of sensory perception. To this end, it is important to assess the demands and potential and respect the dysfunctionalities, anatomical contours and accidents, offering solutions that promote the maximum possible compensation and support, in order to reduce the aggressive agents and the pressure of the environment, in the face of the individual's inabilities. It is therefore a complex process, which begins with its prescription and due to the demand for customization and the infinite combinations of materials and techniques, it is impossible to construct a single text that describes the process of developing all the solutions available to improve biomechanics (MS, 2014, p. 191).

In order to understand the identified need to study how prosthetic architecture can be designed, a study by Butt (2021) presents us with opportunities for developing a common analytical framework that culminates in the growing strength of the natural sciences contributing to the arts and sciences supported by emerging fields such as cybernetics, advanced prosthetic architecture and the latest forms of artificial intelligence, in which the ideas that contribute to the design of prosthetic architecture can contain representative qualities that are proportional to existing building elements, but which simultaneously reinforce their innovative character. In this context, the conceptualization and prosthetic architectural design he aims for consists of exploring and understanding the ideas that contribute to prosthetic architectural design, always considering the possibility of prototyping and technology as support. Therefore, the study assumes prosthesis as one that creates a relationship between two distinct orders: flesh/steel, theory/fiction, translation/citation, public/private, built/unbuilt. It is considered that in order to be successful, prosthetic design needs the right balance between elements (parts of a project) and principles (rules that guide the structure), in which this balance beco-

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mes important in order to instill proportional and formal representative qualities of existing construction elements, while at the same time substantiating new characteristics through different materials. To this end, the right balance between elements and principles, in terms of the success of architectural prosthetics, requires technological advances in manufacturing methods (BUTT, 2021)

DIFFERENTIATING BETWEEN ORTHOSES AND PROSTHESES

It is important to differentiate between prosthesis and orthosis. The word "prosthesis", of Greek origin, is conceptualized as an addition, application or attachment that replaces or adds to a part of the body in order to restore the normal functionality of the human body. The object of this study adopts human interaction with the built environment, with the orthosis as a premise in order to promote support for the user in enhancing their abilities. It is therefore an external device used to compensate for deficiencies in the structure and/or function of the neuromuscular and skeletal systems. As a prosthesis or prosthetic device, it totally or partially replaces a missing or deficient limb segment, and can include any device surgically connected to the limb for structural or functional purposes, for example prosthetic devices anchored to the bone, or even a cardiac pacemaker. The art developed and used to treat people using orthoses is made up of a multidisciplinary team that usually includes doctors, prosthetists, occupational therapists, psychologists, social workers and nurses (ISO, 2020).

The current field of prosthetics/orthotics is an erratic conglomeration of vague guidelines, skills and knowledge. Prosthotology therefore aims to expand and clarify prosthetics/orthotics by disregarding the barriers established between the human body, mind and environment in the traditional scheme, replacing them with goals and goal systems, which are subjective and dependent on the user's perspective and experience. The goal system consists of a goal-setter and a goal-achiever and always considers the expectation set for someone to achieve a goal, which means a desired state. If it is not achieved, the goal is changed. A state is defined as a mode of existence and is derived from the parameters and properties of objects, so everything (and everyone) has a state and a goal is a state transition, and a goal is a desired state as shown in the image below

The goal system is determined by user/environment interaction, with homeostatic preservation as its premise. As the environment is predominantly large, it can be simplified to the perceived environment, and the environment that directly interacts with the goal system and its nodes, or those involved in its realization. From the identification of the state that is considered good or possible, (it forms a goal). A goal setter establishes an objective. For example, an improvement in independence in basic activities of daily living, and so, in response to a stimulus from the (external) environment, based on the physiological-functional abilities of the user's internal goal system, adjustments are proposed to the environment in order to make it as responsive as possible. If the person carrying out the activity is unable to initiate the process to achieve it, the prosthetic concept triggers the aid of a prosthesis capable of providing the correction. But if the difficulty is in propagating the activity already started due to risks and physical barriers, for example, what is known as an orthosis is activated, as corrective support (BACHE, 2008). Similarly, the prosthetics system resembles a reaction with the presence of a catalyst, which reduces the initial difficulties by means of a prosthesis and helps maintain the process by means of the orthosis.

This new perspective focuses on the user's needs and experiences, on what exactly is inhibiting the execution of goals and on the best way to allow them to be fully executed with the least amount of homeostatic wear and tear.

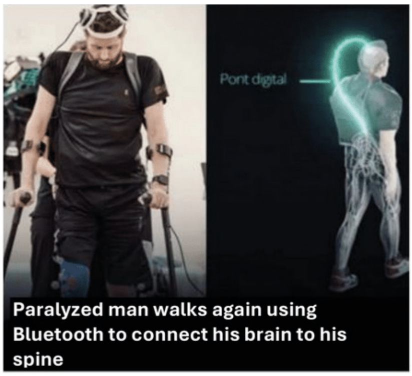
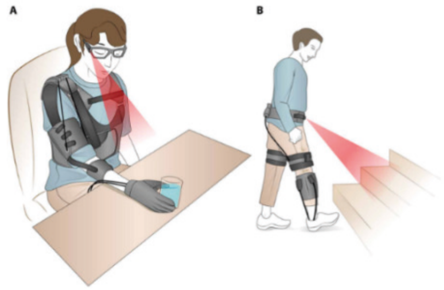
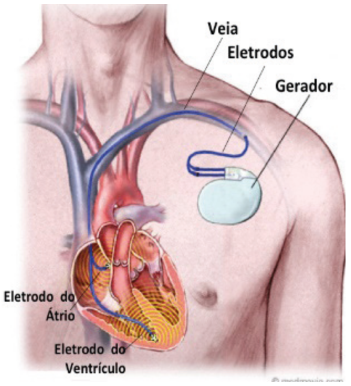
Prosthesis - replaces	**Orthosis** - support
	 
	
	
	
	

Figure 12 - Illustrative difference between prosthesis and orthosis

Source: Google 2024

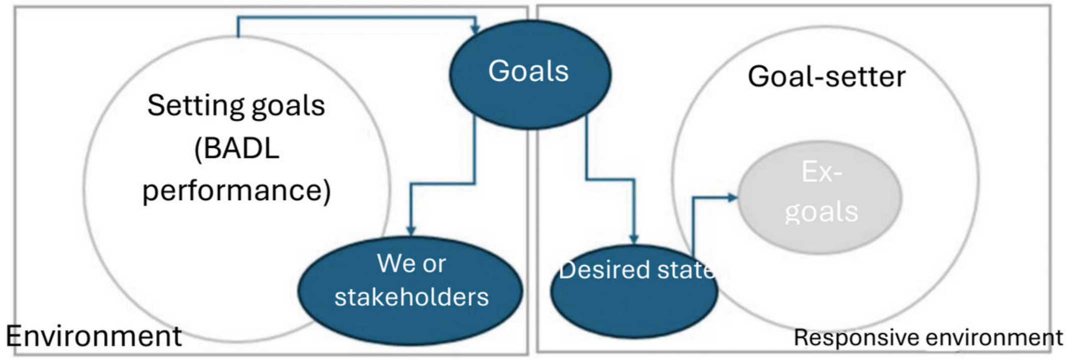
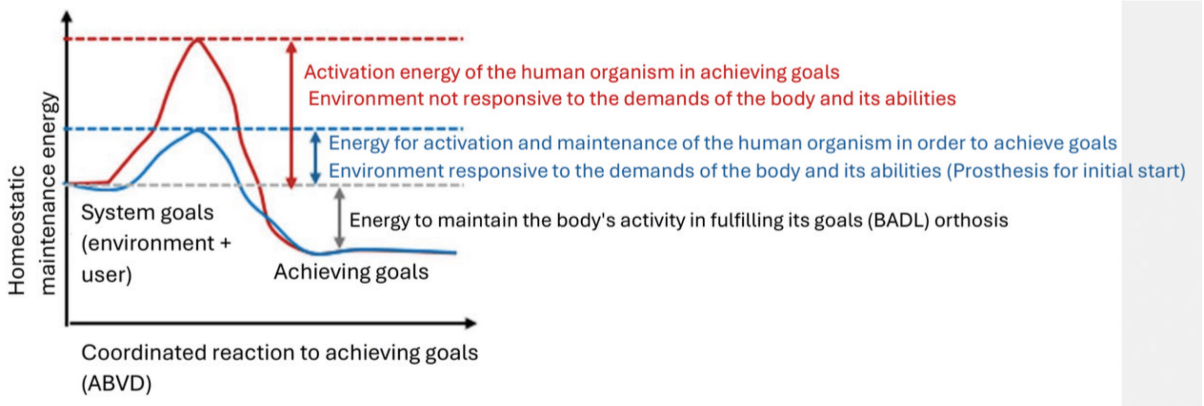


Figure 13: Segregation of the target system based on the environment

Source: Prepared by the author



Graph 01: diagram showing energy expenditure to preserve homeostasis in a responsive environment

Source: Prepared by the author

By not assuming that the human body alone is responsible for achieving a goal, the environment takes on a leading role in the goal fulfillment system. The prosthesis is responsible for the initial start and the orthosis propagates the activity, if we consider the prosthetic concept. It also provides clarification and a structural scientific basis for new products, not just prosthetics and/or orthotics. As such, it understands in a holistic way that the user needs to be treated in a sequential and logical manner. The prosthetic scheme uses a broader perspective to propose a device to the user, be it a prosthesis or orthosis. What this approach allows us to do is understand the demand for assessment of the Clinical Functional Vulnerability Index and potentialities, so that the architect of choice can draw up a prescription or roadmap for implementing improved design support, so that through prosthetic/orthotic solutions it is possible to improve the integration of prostheses and orthoses in an interdisciplinary way (BACHE, 2008).

Prostheses and orthoses are an area of health care and rehabilitation that deals with devices either to replace missing body parts or to assist, restrict, support, immobilize, align and so on, affected body parts. Fragments of historical evidence show that the oldest prosthesis found was made for the aesthetic purposes of the missing body parts of soldiers who lost their limbs in the war. Carbon dating evidence proves its age to be 2,500 B.C. There are some older records of the use of the prosthetic hand in the Rigveda by Queen Wheeplashsa. Until the 19th century, the skill was not widely disseminated worldwide and was limited to small workshops (KUMAR; VINITA, 2020).

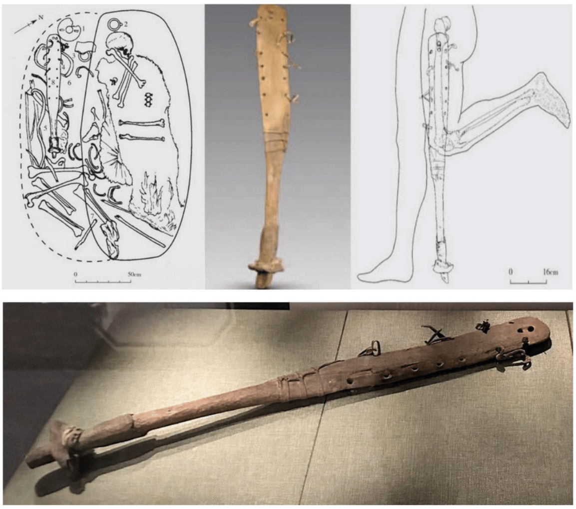


Figure 14: Leg orthosis dating from 2200 BC.
Source: google images

Excavations between 2006 and 2008 at the Shengjindian cemetery, located about 35 km east of the modern city of Turpan in western China, revealed an orthosis dating back 2,200 years BC, from the left leg of a man aged around 65. The tomb also contained the remains of a woman aged around 20. The bones of the man's left knee whose deformed appearance of the patella, femur and tibia, whose cause of fusion may have been inflammation in the joint due to rheumatism or trauma (PUBLISHED, 2016).

Aware of the possibilities offered by the use of life aids, whether through prostheses or orthoses, and considering the house to be an orthosis, which, like prescription glasses, allows us greater comfort and visual acuity, or the use of shoes allows us to walk safely, the idea arose to formalize the concept of the orthosis house. An environment that, if responsive to the demands, abilities and potential of users, through inclusive design and assistive and constructive technology, aims to enhance physiological-functional abilities, for an abundant life and aging in place (AiP)

Promote facilities that include aids for bathing, eating, fall prevention, elimination of physical barriers and environmental hazards, visual detection of obstacles, approach area, transfer/elevation, cooking, emergency call and walking and circulation area for people with reduced mobility. Availability of personal care, as well as communication outside the home and disease management are also necessary. The use of assistive and constructive technology facilitates integrated health care, whether through remote monitoring, medication management and remote physiotherapy, as well as maintaining social networks (LUCIANO *et al.*., 2020)

Obviously, suitable environments for the elderly outside the home must be considered. This includes the immediate surroundings, as well as spatial and urban features at a greater distance from home, such as walkability, supportive neighborhoods that create a sense of community and green spaces. healing environment designs for hospitals. The general principles of age-friendly environments are summarized by the World Health Organization's Age-Friendly Cities concept, which covers age-friendly transport; housing; respect and social inclusion; civic participation and employment; health and community services; information and communication; social participation; and outdoor spaces and buildings. To conclude, good aging in place requires an understanding of needs from the elderly person's point of view and must be personalized. As such, the home environment needs adaptations that are appropriate and responsive to the elderly user (LUCIANO *et al.*., 2020)

HUMAN BUILDING INTERACTION (HBI) OR HUMAN INTERACTION WITH THE BUILT ENVIRONMENT

People today spend 90% of their time in buildings. Therefore, the impact of buildings on human well-being and the environment cannot be ignored. The study of human building interaction (HBI) encompasses the relationship between humans and buildings with a focus on promoting the senses, emotions and comfort of occupants to improve the efficiency, cost and sustainability of the built environment. An interdisciplinary field, it encompasses Human-Computer Interaction (HCI) research and design, building design, architecture and urban design. The buildings and urban landscapes that make up our built environment are primarily composed of physical and spatial elements of protection, whose social value assumes functional and/or cultural significance, as well as providing spatial patterns of relationships and activities. These aspects are developing and changing rapidly in the current era of digital revolution. The integration of network technology and artificial intelligence (AI) creates new forms of interaction in the built environment, transforming and improving the function of spaces, the way of living, the interpretation and analysis of communication between spaces and shaping human interactions with the built environment. Various products and expanding technologies such as smart thermostats, home security systems, multi-room entertainment systems, smart heating systems, ventilation, lighting and power control are increasingly common in buildings. Such technologies show the risk of misalignment between the needs of the resident user and the lack of understanding of the architecture and civil engineering (AEC) industry, alerting us to the importance of the integrated development of information technology in the construction industry. The proper management of this interaction requires the recognition of new multidisciplinary perspectives and the use of new tools and technologies to pave the way for achieving more user-responsive and economically and environmentally sustainable construction, and is a rapidly developing field of research and application (TAHERKHANI; AZIMINEZHAD, 2023).

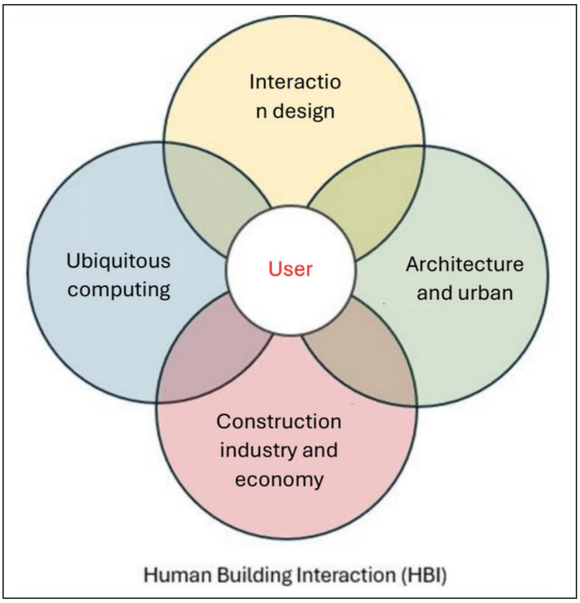


Figure 15: Mapping of areas related to HBI

Source (TAHERKHANI; AZIMINEZHAD, 2023) **Adapted by the author**

The behavior and clinical-functional profile of occupants is an aspect of paramount importance in the investigative context of HBI, in which the responsiveness of the environment generates behavioral triggers that can enhance or diminish the user's abilities, due to the factors involved from the building system, use of assistive technologies, to environmental conditions, which more broadly, integrates three subsystems - *human, building system, and environment* (*HBE*), which are independent and interrelated. It also investigates the execution status of the entire system and explores the interactive relationship between each subsystem. Such information from the overall human-building-environment system makes it possible to understand execution patterns of the entire system and subsystem, as well as the mutual links between each subsystem. The rapid development of sensing technology offers us investigative opportunities to collect more comprehensive information about the entire human-building-environment system. Current HBI research comprises two aspects: (1) occupancy, which involves occupant cou-

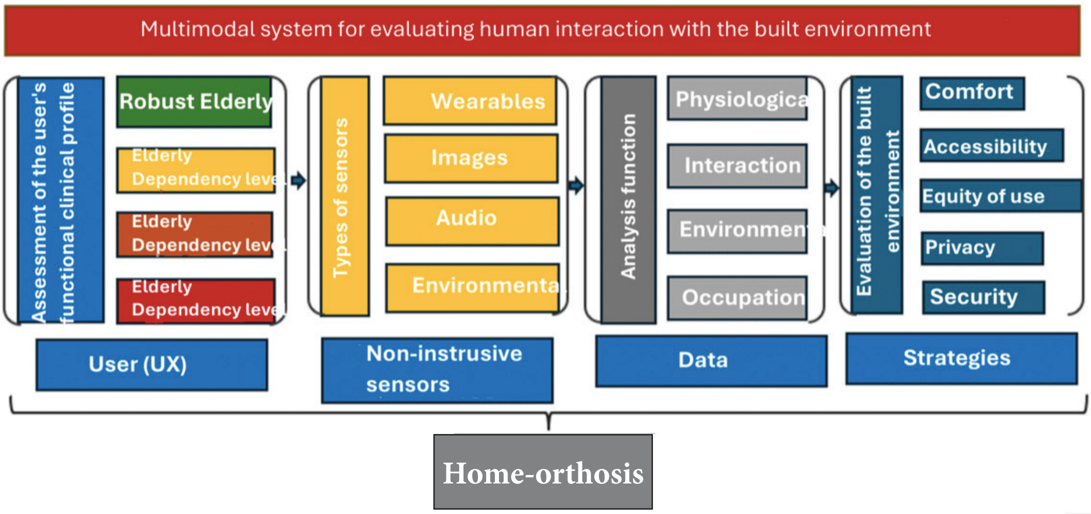


Figure 16: Multimodal system for evaluating human interaction with the built environment in the promotion of data for a sustainable habitability strategy for a house-orthosis that promotes ageing in place.
Source: prepared by the author

Type of evaluation HBI	Function	Detection technology
Occupation	Occupation count, presence of occupation, location of occupation and occupation trajectory	RGB camera and depth camera;
		Active infrared (break beam sensor) Passive infrared (PIR sensor)
		Radial frequency signal, including Wi-Fi
		Ultrasonic sensor.
Users' physiological indicators	Determine the comfort level of users in the building using biosensors and neuroimaging	Related to the human brain (EEG, ERPs, fMRI),
		Muscle and skin (EMG, EDA)
		Cardiac function (ECG).
	Wearable sensors	Wristband with multiple health monitoring functions
Reveal and predict interactions between people and buildings	Detect changes in building components such as windows, doors and floors	Magnetic reed sensor
		Vibration sensor
		Pressure sensor (falls in the elderly)
Environmental sensors	Environmental indicators that make it possible to assess risks and barriers in human interaction with the built environment	Indoor air quality sensor,
		the acoustic sensor
		Illuminance sensor
		Presence sensor
		Smoke and CO2 sensor
		Ambient temperature sensor
		Humidity sensor
		Gas leak sensor
		Air quality sensor
		Water leakage sensor
		Water temperature sensor
		Sensor for changing diapers in bedridden patients
		Position change sensor to prevent bedsores
Energy efficiency index meter	Consumption indicators in time	Energy consumption sensor
		Water consumption sensor
		Photovoltaic energy generation sensor

Figure 17: HBI and the human/built environment/sensor interaction interfaces
Source: Prepared by the author

nt, trajectory and presence; and (2) occupant behavior to control or adjust building system components, including windows, doors, lighting, HVAC system, etc., which is denoted by occupant interaction. An important reason for the building industry's multidisciplinary team when carrying out HBI research is to improve the performance not only of building operations, but also of user activities. Sensing technologies have been organized under various application scenarios: occupancy status, occupant physiological indicators, building component conditions, indoor/outdoor environment attributes, building consumptions and multi-sensor system fusion (JI *et al.*., 2023)

MULTIMODAL MAPPING OF THE BUILT ENVIRONMENT IN LINE WITH THE USER

Brain mapping has been the focus of scientific interest for many years, leading to remarkable developments in technology that allow different aspects of structure and function to be measured. Whether it's coordinating the senses, managing action, regulating emotions or processing our thoughts. Understanding their function in both healthy and diseased states can provide valuable insight into human behavior in the built environment. The development of methods such as electroencephalography (EEG), magnetoencephalography (MEG), magnetic resonance imaging (MRI), positron emission tomography (PET) and functional near-infrared spectroscopy (fNIRS) has propelled the fields of brain imaging and cognitive neuroscience to become dynamic and progressive research disciplines supporting neuroarchitecture. As new technologies develop into routine techniques, a natural progression is to start combining the different technologies to broaden our understanding in a transcendent way, in which multimodal brain imaging takes center stage with EEG-fMRI (WARBRICK, 2022).

A study carried out over a period of 4.8 years, counting from the implementation of sensor-generated health alerts, aimed to compare the length of stay (LOS) of residents living with environmentally embedded alert sensor systems, in conjunction with the implementation of automated health alerts, in contrast to the LOS of those who did not use sensor systems. Sensor technology with care coordination shows the potential for cost savings for consumers and the healthcare system. In addition to estimating potential savings from living with sensor systems, the study shows us that residents living with sensors were able to reside for 1.7 years longer than residents living without sensors, suggesting that the proactive use of health alerts facilitates successful aging in place (RANTZ *et al.*)., 2015)

Health alerts, generated by automated algorithms that interpret data from sensors incorporated into the environment, allow care coordinators to assess and intervene in changes in health status preventively, in the absence of sensor-generated alerts. It is important to note that all residents in both study groups had the same types of care and received care coordination from registered nurses (RNs) as standard of care. The group living with sensors (n = 52) had a mean LOS of 1,557 days (4.3 years); the comparison group without sensors (n = 81) was 936 days (2.6 years); p = 0.0006. The groups were defined based on age at admission, gender, number of chronic diseases (comorbidities/multimorbidities), health physical and mental health. The SF12[1], the Geriatric Depression Scale (GDS), identification of activities of daily living, independent activities of daily living and mental state were used. Cost estimates comparing the cost of living with sensor technology versus a

1. SF-36 is a generic measure of health status that has gained popularity as an outcome measure in a wide variety of patient groups and social surveys. However, there is a need for even shorter measures that reduce respondent burden. The developers of the SF-36 have consequently suggested that a 12-item subset of the items can accurately reproduce the two summary component scores that can be derived from the SF-36 [the Physical Component Summary Score (PCS) and the Mental Health Component

care home reveal potential savings of around US$30,000 per person. The potential cost savings for the funded nursing home (assuming the technology and care coordination were reimbursed) is estimated at around $87,000 per person (RANTZ *et al.*., 2015)

Elderly people have special needs that must be addressed when designing assistive and constructive technology clinical interfaces aimed at them, especially health information in the interaction between these users and their support network, whether formal or informal caregivers. It is therefore important to evaluate the human factors of clinical information during user interactions with systems. These requirements should be adopted as assumptions before implementation (ALEXANDER et al., 2011)

FINAL CONSIDERATIONS

We are getting older, and in this chapter we have been able to navigate the evolutionary history of residential environments and mechanization. Today, all these attributes of technology and design seem intrinsic to our daily routine. But we forget the whole development process, often anonymous, behind so many facilities. Whether it's running hot water when you turn on the tap. Or when you flush the toilet. Or even heating water in the microwave for a comforting cup of tea at the end of a stressful day. To lie down and sleep on an orthopedic mattress, with the ideal density, and fresh-smelling bedding, so that the next day, with all your hormones in order and your mind reset, you can face a new day. These and so many other seemingly mundane items of usability and comfort make us fortunate. In the 2000 movie "Shipwrecked", Tom Hanks shows us this whole interface in a sublime and delicate way. The clock shows us the marking of time, a social convention of modern times, and our fragility in the face of it, which is relentless. The ball, Wilson, allows us to understand the human need for belonging and sociability, because a solitary life is merciless. Powerlessness in the face of a tooth that hurts, a cut on the leg, the lack of clothes and shoes, orthoses that allow us to live a more dignified and comfortable life. The countless attempts to produce and control fire, to handle rudimentary fishing tools. In this masterpiece, Tom Hanks, in line with everything we've seen in this chapter, explores the concept of usability and the activities of daily life, such as turning on a light and turning it off with a simple touch, or the abundance of a table full of seafood, food that was difficult for him to obtain with the scarcity of resources created by contemporary society. The silent rhythm that the protagonist takes on, after all the transformation he goes through as he comes face to face with what is essential to life. At the end, when he draws a parallel between the sea and life, he asks us what the sea brings us today. It's like the challenging process of life. Growing old requires resilience, wisdom and a lot of courage.

Understanding the demands placed on the body by the adversities faced throughout life today allows us to be more lucid when proposing habitability strategies that are responsive and compatible with an abundant life. Despite the physical, biochemical and metabolic dysfunctions of the senescence or senility process, the built environment provides us with support to carry on. Our daily choices make us more or less healthy throughout the process. This fact must be understood and taken into account when implementing constructive and assistive technology for human interaction with the built environment, right from the design phase by the architect, together with the multidisciplinary team. A home-orthosis not only brings us welcome and belonging, but also has the obligation to enhance skills for greater independence in BADLs so that the choice of ageing in place (AiP) is an active and abundant life.

Summary Score.

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