



# Landscape Design and Neuroscience Cooperation: Contributions to the Non-pharmacological Treatment of Alzheimer's Disease

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**Abstract.** Research studies on neuroplasticity suggest that architecture and design have the potential capacity to alter the brain structure and its functions. With regard to constructed healing spaces, the landscape design project acts as a key feature in clinics that treat patients with Alzheimer's disease. The relationship between the patients and nature is essential because living in a green area has a number of positive effects such as the following: adjustment of the patients to their circadian rhythm; an increase in the production of Vitamin D; basic notions of time; better quality air and a wide range of stimuli. Thus the landscape and architectural features of a green environment play a key role in the sensorimotor and cognitive stimulation of the patients. Against this background, this paper seeks to investigate how there can be the collaboration between the area of landscaping and neuroscience, especially with regard to a comprehensive list of recommendations involving therapeutic design gardens, with a view to offering non-pharmacological treatment to patients suffering from Alzheimer's disease. The 38 proposed recommendations that were set out, are based on a review of the literature and a research field carried out in the wards of a center for elderly people requiring care called 'Recanto Monsenhor Albino' [Monsignor Albino's Rest Home], located in the town of Catanduva (Sao Paulo – Brazil). The main benefits that can be highlighted include the set of guidelines for the project, together with an analysis of therapeutic gardens and the quality of life and well being of the people in this environment.

**Keywords:** Landscape design · Neuroscience · Alzheimer's disease  
Non-pharmacological treatment · Therapeutic gardens · Guidelines on design

## 1 Introduction

The first links made between the fields of knowledge of Neuroscience and Architecture occurred at the end of the 1950s, in response to the need for an understanding of how human beings perceive, experience and interrelate with constructed space.

As an example of this, it is worth drawing attention to the work of the doctor Jonas Salk. At this time, which was for him a decisive moment for undertaking research, Salk discovered and developed one of the first vaccines against poliomyelitis. This achievement was made while he was staying at a 13th Century monastery in Assisi in Italy. Salk

claimed that being able to interact with the setting of that locality proved to be a stimulus for new methods of thinking and research. Since he was persuaded of the capacity of architecture to alter a human being's way of acting and thinking, and the influence that the features of one's surroundings can exert on someone's physical and mental health [1], Salk invited the architect Louis Kahn to set up the Salk Institute in La Jolla – California. This was a place designed to act as an incentive to creativity and to stimulate advances in Science [2].

As a result, the link between these areas began to be strengthened as a means of finding a response to the kind of questions that emerge in investigations of this nature and bringing benefits to those who design or dwell in the created space.

Currently, there are several research studies which are within the scope of neuroscience, architecture and design and these have gathered momentum with the increasing importance of this field of knowledge. Research studies of this kind [1, 3–21] are devoted to studying the complexity of the human brain and how it is influenced by different spaces and interfaces.

Among the significant contributions made by neuroscience to architecture and to design, it can be stated that Neuroplasticity is related to the way that the environment models and modulates the human brain throughout our lives. Neuroplasticity is the capacity of the brain to be molded and adapted both in the structural and functional spheres either during its development or when subject to new experiences and surroundings. This feature of the nervous system ensures that the neural circuits are malleable and interfere directly in forming and establishing the memories and learning as well as adjusting to lesions and traumatic events [22, 23].

This capacity for transformation continues in the brain even after the specific stages of its formation and is closely bound up with (i) the surroundings in which it is embedded; (ii) the substances with which the brain is nourished; and (iii) the degree of neural stimulation by means of which this potential capacity for alteration and adjustment is either increased or neglected [10].

All internal and external stimuli shape the behavior of any living being, from the simplest to the most complex organisms, such as human beings. According to Pallasmaa [18], the brain controls human behavior, whereas the genes control the brain structure. The environment can modulate the function of the genes and ultimately the brain structure. In other words, changes in the environment alter the brain and hence change the behavior of the individual. It is within this analytical framework that architecture and design play a crucial role in shaping the experience of the individual within his/her world. In other words, the architecture and design mediate a bond between the body and the environment and within this mediation, the space that is formed acts as one of the main interfaces that assist in the process of neuroplasticity.

Thus if “the architecture is the constructed mental space” [18], the project externalizes the human mind. At the same time, owing to the neuroplasticity, the human brain is sensitized and designed by these materializations of the mind. Everything that is constructed is supplied by the human mind while the brain is altered with regard to everything that is constructed. The spaces formed by the architects/designers explore the opportunities that go beyond these functionalities and everyday uses. They are the embodiment of the wishes and needs of those who inhabit them. These kinds of expectations are present in human minds and they are externalized by architects and

designers through the different opportunities they offer for constructions, while at the same time, the inhabitants internalize all the opportunities that the spaces offer [19].

Farling [20] states that, “when designing spaces, we alter our behavior and the capacity of our brains”. Hence, understanding the brain functions and how an individual perceives, understands and acts in space, is becoming essential when designing environments that are suitable and congenial to their users. Exploring what neuroscience is able to offer can provide architects/designers with the capacity to design even more complex models with regard to environmental-perceptual-behavioral interaction.

This means that, apart from their scientific added value, investigations that focus on human behavior with regard to constructed space, can lead to significant benefits: (a) the project process of architects/designers; (b) project analysis; and (c) to the users of these environments, especially when they are suffering from neurological diseases that impair their cognitive functions, such as that caused by Alzheimer’s disease.

Currently, the number of people diagnosed with Alzheimer’s disease or other types of dementia, exceeds 47 million throughout the world, more of a million of whom are living in Brazil. Alzheimer’s disease is a progressive brain disorder and although it unfortunately has no known cause or cure, it can be treated.

The main objectives of pharmacological and non-pharmacological treatments are to alleviate existing symptoms by stabilizing them or at least allowing a large proportion of patients to progressively slow down the disease so as to preserve their independence in daily activities for as long as possible.

In the context of non-pharmacological treatments, constant and diversified cognitive stimulation throughout the individual’s life is a way to slow down the disease process, once it can bring benefits to the maintenance of skills that are still preserved. The purpose of this type of stimulation is to minimize patients’ difficulties from compensatory strategies so that they can make consistent use of intellectual resources still available.

Against this background, this paper seeks to make a contribution by investigating the degree of cooperation between the areas of the landscape design and neuroscience, especially with regard to a comprehensive list of recommendations for designing therapeutic gardens, with a view to offering a non-pharmacological form of treatment for patients afflicted with Alzheimer’s disease.

The results obtained cover a total of 38 drawn up recommendations and are based on a review of the literature and research field carried out in the precincts of the center of care for the elderly called ‘Recanto Monsenhor Albino’ [Monsignor Albino’s Rest Home], located in the town of Catanduva (Sao Paulo – Brazil). In the sphere of the landscape design, the extent of the list of recommendations indicates which design features are essential for the sensorimotor and cognitive stimulation of these patients.

## **2 Man-Nature-Landscape Design: Widening Constructed Space**

There is an intrinsic relationship between human beings and nature, which pervades the whole of existence [24]. It is an almost unconscious affinity, which has been called as Biophilia [25], and leads man to appropriate all the features that nature can offer and

make them form a part of his own history. Grinde and Patil [26] argue that an individual's need to make use of the resources of nature in his day-to-day life is caused by the biophilic design of his mind.

At the same time, the responses to stimuli prompted by nature, are linked to the memories formed during one's own life. Colors, smells, flavors, textures and all the sensations caused by nature, are factors that enhance the affective memory, as well as the memories that are stimulated through experiences that arouse emotions and feelings. This means the individual is biologically prepared to feel secure and relaxed in natural environments and in spaces laid out with green areas. Differences in culture can explain the preference for natural spaces but the deepest and almost unconscious relationship the human being can have with nature, seems to be genetic [27].

Through its restorative, soothing and therapeutic qualities [27], nature is able to provide a state of well being for man in many ways such as through: the fragrance of a flower; the rustling of the breeze blowing through the trees; the awareness of different textures when touching the surface of plants; the influence of a microclimate which is responsible for mitigating humidity and improving the purity of the air [26]; a considerable reduction in levels of stress compared with those experienced in urban environments [28]; and cognitive improvements of a high order.

As well as the numerous pharmacological and non-pharmacological benefits that nature provides (the former confirmed by scientific studies), there is an interaction of human beings with the area of architecture related to nature – landscape design.

Landscape design is a vital part of architecture, which is directly related to the person who experiences it. It is the area of architecture that is closest to the primitive relationships of human beings or more precisely, what allows an encounter between the individual and his/her origins [29].

Landscape design covers areas that are free and not built for residential purposes, work or services and appropriates these spaces to shape a new landscape based on the interpretation of the social behavior of a community. In this context, the landscape design is a form of language, an element of communication that acts directly on the individual's awareness of space, involving their five senses [30]. For this reason, understanding the relations that the human being establishes with nature is essential to ensure that the constructed space meets the needs of the people who inhabit it [19].

The planning of a landscape project entails both arranging natural features such as plants, rocks, water, light etc., and incorporating architectural features such as roads, pergolas, outdoor furnishings, and kiosks which assist in creating space that is formed in a natural setting. In reality, the raw material of a landscape design project "does not consist of flowers, stones or trees but feelings" [30]. Moreover, it is by articulating the design features – lines, shapes, texture, colors, movements, sounds, smells and the main aesthetic attributes, that the emotional experiences are constructed and provided to human beings. In other words, when a landscape design project includes the relationship human beings forge with nature, as well as meeting the needs of the people who inhabit this respective space, the planned decisions covered there, will be responsible for inducing positive emotional and cognitive changes, as well as benefiting people's health and well being [31].

In this area, landscape design projects are included for therapeutical purposes and devoted to the treatment and recovery of patients, either temporarily or permanently suffering from illnesses or health syndromes.

### **3 Health and Well Being: Landscape Design Projects for Therapeutical Purposes**

The monastic spaces found in Europe in the 15th Century which were generally surrounded by cloisters and arches, characterize the first dwellings in which gardens were deliberately included as a part of the healing process. Two examples of these are the hotels-Dieu (“hostels of God”) and the Cistercian abbey of St. Bernard de Clairvaux (in France). Kaufman and Warner [32], argue that this indicates the intuitive perception of the sensory information that gives Nature its meaning as a significant factor of the healing process for the well being of those who inhabited these environments.

From 1450 onwards, the concern with contagious infectious diseases that could be transmitted through the air, restricted the monastic gardens to being used as infirmaries, as a strategy to control the spread of diseases. Moreover, it was only at the end of the 15th century and beginning of the 16th Century that the architects of the infirmaries tried out a new conception of therapeutic space, which included the use of sunlight, the circulation of air and green areas. This idea was directly influenced by the set of aesthetic features introduced by the Arabs, which included arcades, patios and windows that allowed the air to circulate and shed sunlight on the patients - all of which resulted in an improvement in their state of well being.

Apart from their spatial configuration, these changes even went so far as to train personnel to work in these hospitals. As a result, activities in the fresh air, physical exercises and socializing, began to form a part of the everyday routine of the patients.

However, the first attempt to make recommendations for designing hospital gardens only appeared in the 18th Century when Christian Cay Lorenz stated that: “[...] a hospital garden should have everything to enjoy nature and to promote a healthy life [...] it should be close to the hospital or even better surround it [...] a view from the window onto blooming and happy scenes will invigorate the patient [...] a nearby garden also encourages patients to take a walk [...] the plantations should wind along dry paths that offer benches, [...] colored leaves and blossoming and fragrant shrubs and flowers [...]” [32].

During the First World War (1914–18) significant benefits were obtained from open and green areas in the treatment of the wounded which is borne out by the significant recovery rates and an exponential reduction in the mortality rates in hospitals that used therapeutic gardens as a part of their treatment.

Since then, there has been an understanding of the value of the landscape design project in healing environments. This has been strengthened by advances made in a number of research studies [6–9, 24, 29, 31, 33–36] which been able to attest to the positive effects that the stimuli of outside spaces and therapeutical gardens exert on the brain and hence on the restoration of health to human beings.

### 3.1 The Landscape Design Project in the Non-pharmacological Treatment of Alzheimer's Disease

Each person understands designed space in different ways. Moreover, in this area, memory plays a key role in guiding people to these spaces and forwarding the meanings to them. On this basis, it can be understood what damage has been caused to the perceptions and spatial experience of people with brain injuries resulting from neurological syndromes and ailments, which affect the memory, like Alzheimer's disease.

Alzheimer's disease was first described in 1906 by the German psychiatrist and neurophysiologist, Alois Alzheimer. It concerns a progressive neurological illness and is still fatal. It is responsible for slowly and gradually impairing the functions of the brain and is characterized by its harm to two or more of the following cognitive functions: memory, language; attention; logical reasoning; judgment; planning; visual and spatial skills. Moreover, it is sufficiently serious to have an adverse effect on the everyday life of someone afflicted with it. Among the high levels of cognitive failure, behavioral problems and psychiatric symptoms that the patients of Alzheimer's disease are subject to, hallucinations, depression, physical aggression and alterations in sleep patterns are conditions that should be highlighted.

In other words, the damage to the brain caused by Alzheimer's disease is, at the moment, something that is irreversible and in a significant way, can alter the whole intellectual, affective, behavioral and ultimately physical functioning of the individual concerned. Gradually, the patient loses his/her capacity to think, learn, remember, communicate or carry out everyday activities in an effective and independent way, as well as to manage his/her life in an autonomous way, since this person requires constant care [37].

Age is the major risk factor for the development of Alzheimer's disease. After 65 years of age, the risk of developing the disease doubles every five years.

According to the Alzheimer's Association [38], nearly 47 million people are believed to be living with Alzheimer or dementia worldwide. This number is predicted to increase to almost 75 million by 2030 and almost 132 million by 2050. And according to the Center for Disease Control and Prevention [39], an estimated 5.1 million Americans, aged 65 or older, may currently have Alzheimer. This estimate may rise to 13.2 million by 2050. In Brazil, there are about 1.2 million cases, most of which are still undiagnosed [40].

Although there is still no cure for Alzheimer's disease, some studies [9] suggest that if the illness is treated in its early stages, soon after the first symptoms have been detected, measures can be taken to control its progression. There are two kinds of treatment for Alzheimer's disease – pharmacological and non-pharmacological.

Whereas pharmacological treatment is based on the use of medication to ease the advance of the disease, non-pharmacological treatment makes use of several kinds of therapies, which entail exposing the brain to several kinds of stimuli. The purpose of this is to arrest the advance of the disease and provide a sense of well being for patients with these conditions.

It is worth drawing attention to the concern with projected space – for inside and outside places - when offering non-pharmacological treatment. According to Zeisel [8], people suffering from Alzheimer's disease need to live in secure and carefully planned environments because among other problems linked to the disease, they have great

difficulty in remembering the spaces they have visited as well as being able to locate these environments. Patients with Alzheimer's disease have difficulty in remembering the place where they were only a few minutes before.

On the other hand, those affected by the disease (and other patients too) tend to be healthier when support is given to making them feel secure and interact in a friendly way. This is because the environments planned for this purpose create the right conditions and sensorimotor stimuli for the enhancement of cognition and sensitizing the spatial perception of these patients and hence enable them to get their bearings in this space. These kinds of stimuli allow the brain to respond in a positive way to the created space and as a result, the patients are able to walk from one point to another with the aim of arriving at a particular place and knowing exactly where they are. As well as triggering a stimulus to spatial perception, environments of this kind also provide areas devoted to a wide range of activities with therapeutical goals such as physiotherapy, music therapy, gardening, and painting. They are also geared to enabling the patients to socialize between them and with their families.

This means that these kinds of environments can assist the patients in being conscious of who they are and what they are doing and this is a strong support to the independence and health of people in these conditions. Thus the landscape design project of clinics that offer homes to patients with Alzheimer's disease plays a crucial role in their care and non-pharmacological treatment by providing them with a healthy period of residence in this healing space. This includes the positive emotions and feelings aroused by the outside environment and gardens which are responsible for: (i) the significant reductions in stress, agitation and aggressive behavior; (ii) a greater production of Vitamin D; (iii) a significant improvement in sleep patterns, hormonal balance and the quality of life of these patients. Examples of this are: the healthy sensations caused by sunshine, fresh air, breeze and the temperature of the skin; a view of nature, colors and the textures of plants and flowers; the pleasures of gardening and the chance to go for walks, feed the birds, take exercise and socialize with friends [24, 31, 33, 34] among other kinds of stimuli that are able to sensitize the physical and psychological domains of a person in a satisfactory way.

In this sphere, the spatial configuration of the healthcare centers for patients with Alzheimer's disease and other forms of dementia are altered and molded with a view to offering them environments that resemble a residential dwelling. Relatively small clinics which recreate the feeling of a home, are the opposite of what is found in large impersonal hospitals and are becoming increasingly common because patients suffering from dementia tend to behave better and have a more pleasurable life in this type of accommodation [41].

The feeling of home is increased by the presence of therapeutical gardens in the landscape design projects of these clinics. They allow patients suffering from Alzheimer's disease to take up gardening as a form of therapy. In general, plants significantly benefit the physical and psychological well being of the residents. In particular, plants or flowers familiar to the patients play a key role in evoking affective memories. In addition, the need to take care of plants which is involved in gardening, assists in the maintenance of motor skills and offering positive forms of sensory stimuli, as well as being a topic of conversation between the patients and personnel who take part in this activity. Through the active interaction between patients with limited motor skills, it is recommended that plants



should form the project of a therapeutic garden that should also take account of tolerance to rough treatment or excessive irrigation of the plants [29].

There are a number of suggestions in the literature [6–9, 29, 31, 35], which make a wide range of recommendations for designing therapeutic gardens and take account of different levels of neurological and physical involvement for patients with Alzheimer’s disease. With regard to the scope of this research study, these recommendations can be divided into eight categories: (a) access; (b) pathways; (c) uses; (d) particular activities; (e) comfort; (f) planting/sensory stimulation; (g) spaces/stimuli; (h) security and conservation – as set out in Table 1:

**Table 1.** Scope of recommendations for designing therapeutic gardens.

Access	Pathways	Uses	Particular activities
Number of doors/gates giving access to the garden	Complexity of the paths for the patients	Gardens separated owing to the different levels of Alzheimer’s disease	Areas set aside for manual activities that involve horticulture and tilling the soil
Bathrooms near the garden	Signs of landscape features that can attract the attention of the patients during their walks	Factors that encourage the residents to help in looking after the garden	Areas suitable for physical activities like physiotherapy and organized walks
Freedom of access to the garden	Layout to indicate the pathways	Uses of the garden by the staff at the Center	
		Uses of the garden by the families	
		Uses of the garden at nighttime	
Comfort	Planting/sensory stimulation	Space/stimuli	Security and conservation
Location of the chairs and benches to allow patients to rest	Existence of plants with shapes/aromas that can provoke irritability	Architectural features that can evoke memories or types of behavior that can stimulate the brain	The existence of emergency exits
Presence of seats and shade for the hot period after midday	Plants and flowers with vivid colors	Landscape features of the garden that linger in the past of the patients and can evoke memories	Ensuring the patients are able to see the perimeter surrounding the garden
	Plants that undergo seasonal changes and seasonal plantation	Shape of plants, structures, shade, statues and suchlike that can provoke hallucinations or illusions	View of the garden from within the building
			Existence of poisonous plants
			Existence of plant species with sharp edges that can hurt the patients

Source: the authors.



Setting out from this range of recommendations, an investigation is carried out into the ‘Recanto Monsenhor Albino’ [Monsignor Albino Rest Home] clinic, which is specialized in the treatment of elderly people with dementia, such as that caused by Alzheimer’s disease, and located in the town of Catanduva (Sao Paulo – Brazil), as described in the following section.

#### **4 The ‘Recanto Monsenhor Albino’ Landscape Design Project**

This research field study was carried out during December 2017, in the precincts of the ‘Recanto Monsenhor Albino’ rest home located 4 km from the Dr. Alberto Lahós de Carvalho highway in the town of Catanduva, in the Northeast region of the State of Sao Paulo (Brazil), and 384 km from the capital, Sao Paulo.

Currently, the clinic is run by the Sister Anália Nunes, and includes a staff of doctors, nurses, a nutritionist, an occupational therapist, a psychologist, a physiotherapist and a social assistant. The place seeks to welcome elderly people over the age of 60 of both sexes and offers them apartment suites or simple bedrooms. It has the capacity to accommodate 50 elderly people and is divided into female and male wards.

The method for gathering data entailed the practice of regular visits to the space in question and conducting interviews with the staff of health cares. Moreover, as in the case of the method employed for the analysis and interpretation of the results obtained, the study followed the full range of recommendations for designing therapeutic gardens based on the ideas of Zeisel [6–9] Marcus e Sachs [29]; Pappas [31]; and Hernández [35].

The ‘Recanto Monsenhor Albino’ possesses a farm that was donated by the Rotary Club of Catanduva. This covers an area of 240.220 m<sup>2</sup>, where buildings have been erected for both men and women, which are sites for nursing and visiting rooms. There are also buildings with offices for administration, social services and psychology, together with a canteen, toilet facilities, a kitchen a room fitted for physiotherapy, and a chapel for prayers and religious services. In addition, there are spaces for doing physical exercises and socializing with the patients, as well as green areas for walks and gardens where vegetables are grown for their own consumption.

The clinic was opened in the middle of February 2001. The families of the elderly guests are allowed to take part by making daily visits between 10:00 and 17:00 h. The patients usually have meetings with their families in the outside area of the rest home in Praça da Amizade [Friendship Square].

The main access to the place was through a gate, which remained open the whole day and was the place where pedestrians and cars entered the premises. The cars were parked in front of Praça da Amizade [Friendship Square]. This is the square where the families stay during their visits and it includes a grotto dedicated to the Blessed Virgin Mary.

There is a pathway covered with awnings which has handrails throughout its length and leads the visitor or patient (both male and female) to their wards where are situated their sleeping quarters, the dining-room, the chapel and the physiotherapy rooms.

Both the women’s ward and the men’s ward are similar and have either individual suites or rooms for two people. These bedrooms have windows that open out to an

expansive green area. The building for the female ward has a larger area because the number of women with Alzheimer's disease tends to be larger than that of men [43].

The chapel, physiotherapy rooms and dining-room were built separately and interlinked by walkways as a means of encouraging walking, since the topography of the site is designed to make it possible to walk without difficulty.

At the back of the dining room, there is a large kitchen garden enclosed by a hedge, where several kinds of vegetables, greens and other produce are grown with the assistance of the patients, for their own consumption.

The free and green area of the center is significantly larger than the covered area. In addition, the presence of animals such as cats, hens, turkey and various birds helps to give a greater spatial resemblance to a farm and this distinguishes the 'Recanto Monsenhor Albino' from other clinics that offer homes to patients with Alzheimer's disease.

The types of flora that can be seen mainly consist of green foliage. The uniform green area is suited to walking, making observations and the time spent there by the patients and their families. However, there is no garden for activities to be carried out together with the residents.

The activities that take place in the open air usually involve special events on commemoration days. The other everyday activities of the patients are carried out in closed environments such as the physiotherapy room. However, all indoor environments are connected directly to the green area. In the same way, access to these places necessarily requires the elderly people to walk through green areas.

## 5 Results and Discussion

This section sets out the results obtained from the analysis of the landscape design project that centered on the 'Recanto Monsenhor Albino' rest home, and includes a discussion based on the features that make up the list of recommendations for designing a therapeutic garden (Table 1) and the contribution made to this project made by practice in the field.

### (a) Access to the Garden

Following the research studies carried out by Zeisel [6–9] and Marcus and Sachs [29], the recommendations for the project in the 'Access' category include: (1) the number of doors/gates that give access to the garden; (2) the bathrooms closest to the garden; (3) freedom of access to the garden. At the same time the work undertaken in the field study broadened the scope of this inquiry by incorporating two new features: (4) ease of access to the garden by the patients; (5) accessibility as outlined below (Table 2):

The exits from the wings providing the patients with access to the garden are indicated in a satisfactory way. However, this pathway might be confusing for the residents because of the various outbuildings and gates. In light of this, it is recommended that the paths should have pointers that can serve as guides for the patients, with colored floors and handrails for identification (for example, red for the dining-room, blue for the chapel, and yellow for the physiotherapy rooms). These pathways are quite extensive for the patients.

For this reason, it is recommended that sanitary facilities should be installed that are separate from the huts and set up along the paths. This would allow the residents to make use of the bathrooms without having to enter the huts. This measure is of crucial importance since patients with Alzheimer's disease suffer from incontinence soon after the beginning of the second phase of the disease [29, 37].

**Table 2.** Scope of recommendations for the 'Access' category.

Access	Results	Commentary
Number of doors/gates with access to the garden	<b>[Partly addressed]</b>	There is a door that gives access to the garden in each wing (male and female). However, owing to the fact that the outhouses or huts are detached from the wings, the patients can feel confused when following the path that provides access to the garden
Bathrooms close to the garden	<b>[Partly addressed]</b>	Each hut provides toilet facilities. However, owing to the distance between each of the huts, there is an insufficient number
Freedom of access to the garden	<b>[Fully addressed]</b>	The doors of the wings remain open for the whole of the day
Ease of access to the garden by the patients	<b>[Fully addressed]</b>	The green area of the clinic covers a significant part of the terrain and the way it is designed allows the patients to have ease of access to the garden
Accessibility	<b>[Fully addressed]</b>	Ramps and handrails can be found in all the pathways giving access

Source: the authors.

The way the clinic is designed meets all the requirements with regard to accessibility and allows the patients, visitors and staff of cares to enter the green area without any difficulty. Since contact with nature is immediate and extended to the whole terrain, anybody can easily enjoy the benefits of the garden of the clinic. The doors and gates providing access to the garden are kept open so as to encourage the patients to make use of the green area, as well as to be able to walk about freely.

### (b) The Garden Paths

Following the suggestions made by Zeisel [6–9] and Marcus and Sachs [29], the design recommendations for the 'Paths' category cover: (6) the complexity of the paths for the patients; (7) Signs of landscape features that might attract the attention of the patients during their walks; (8) Layout that suggests what pathways can be taken. And as a result of the procedure followed in the field survey, a new factor has been added to this: (9) the gentle topography for both walking and resting patients, in accordance with the description given below (Table 3):

**Table 3.** Scope of recommendations for the ‘Paths’ category.

Pathways	Results	Comments
Complexity of the paths for the patients	<b>[Partly addressed]</b>	The pathways are set out with clearly defined areas, awnings and handrails
Signs of landscape features that might attract the attention of the patients during their walks	<b>[Partly addressed]</b>	There are features such as: a grotto for Nossa Senhora Aparecida [Our Lady of the Appeared Conception (one of the titles of the Virgin Mary)]; and species of tall plants that stand out
Layout that suggests what pathways can be taken	<b>[Fully addressed]</b>	The whole pathway is created by a different layout
Gentle topography for both walking and resting patients	<b>[Fully addressed]</b>	The terrain is sufficiently flat and relaxing for the patients

Source: the authors.

The design of the clinic includes an arrangement of pathways fitted with handrails, differentiated floors and awnings that connect one hut from another so that both the staff and residents can clearly make out which path to follow. However, owing to the monotony of the colors, textures and shapes, the patients can easily be confused. It is recommended that these paths are distinguished more clearly and have contrasting features so that they can guide people more effectively. In addition, distinguishing marks in the landscape are essential to enhance the stimuli provided by the pathways since these can be understood by the patients as reference-points of their location. This means increasing the number of distinguishing features spread around the garden such as fountains, statues, benches, and large-sized plants.

With regard to its topography, the terrain of the clinic was found to be flat enough and congenial and allowed the patients autonomy and ease of movement when walking. As it grew, it was suggested that occasional, gentle slopes could be included as a means of helping the residents do exercises.

With regard to the layout, the pathways are indicated by the concrete floor, iron handrails and awnings made of translucent polystyrene tiles. These paths link one hut to another and are in direct contact with the garden. For the benefit of the residents, a new feature should be added to this layout, which is the idea of having a pathway in the middle of the garden with the use of comfortable wooden duckboards.

### (c) **The Uses that can be Made of Gardens**

With regard to the ‘Uses’ category, Zeisel [6–9]; Marcus and Sachs [29]; Pappas [31]; and Hernández [35] make the following recommendations: (10) separate gardens for different levels of Alzheimer’s disease; (11) features that encourage the patients to help in taking care of the garden; (12) uses of the garden by members of the staff; (13) uses of the garden by families; (14) uses of the garden at nighttime. On the basis of the procedure followed in the field research, a new factor is put forward for this area: (15) design of the garden for therapeutical and socializing purposes and a number of activities involving all the patients such as the following (Table 4):

**Table 4.** Scope of recommendations for the ‘Uses’ category.

Uses	Results	Comments
Gardens separated to take account of different levels of Alzheimer’s disease	<b>[Not addressed]</b>	All the patients are free to enjoy the same areas of the garden
Factors that encourage patients to help with looking after the garden	<b>[Partly addressed]</b>	Apart from the kitchen garden at the back of the clinic, the patients do not actively take part in looking after the garden
Uses of the garden for members of the staff at the center	<b>[Fully addressed]</b>	All the staff stated that they made use of the garden for purposes of relaxation, contemplation and socializing
Uses of the garden by the families	<b>[Fully addressed]</b>	It was noted that it was widely used by the families during their visits
Uses of the garden at nighttime	<b>[Not addressed]</b>	The garden is not used at nighttime
Shaping of the garden for therapeutic practice socializing and various activities with all the patients	<b>[Partly addressed]</b>	Although the area is suitable for distinct activities, these are carried out in closed environments

Source: the authors.

Since all the patients with Alzheimer’s disease respond to stimuli in different ways during the different stages of the disease, it is recommended that there should be specific areas in the garden devoted to differentiated types of cognitive stimulation that are aligned to the stages that apply to the residents of the clinic.

With regard to the question of looking after the garden, this was shown to be essential since it acts as sensory therapy and assists in establishing a daily routine for the patients. In view of this, features should be included in the green area that allow residents to react in an active way to this space.

In the case of physical, therapeutic and socializing activities, although the green area of the clinic offers good prospects for these uses, it is restricted to the space allotted for meetings between the residents and visitors by the ‘Praça da Amizade’ [Friendship Square], which provides the features of rest and relaxation, such as benches and shade. Thus, in light of its potential uses and significant benefits, it is strongly recommended that activities focused on encouraging the patients to linger in the garden should be expanded.

This can be extended to the use of the green area at nighttime. At all events, it is essential to renew the current installations and a scheme for illuminating the gardens could be put into effect. At the time of the field research, the existing lighting system proved to be insufficient to allow patients to walk about at night.

#### (d) Carrying out Specific Activities in the Garden

With regard to the ‘Specific Activities’ category, Marcus and Sachs [29] and Pappas [31] make the following recommendations: (16) there should be areas devoted to manual

activities that involve horticulture and tilling the soil; (17) areas suitable for physical activities such as physiotherapy and walks. On the basis of the process followed in the field research, two new items are included: (18) involvement of the patients in looking after particular garden species; (19) gathering species for uses that entail manual activities such as those described in the following chart (Table 5):

**Table 5.** Scope of recommendations for the ‘Specific Activities’ category.

Particular activities	Results	Comments
Areas designated for manual activities that involve vegetable gardens and tilling the soil	<b>[Fully addressed]</b>	There is a large kitchen garden for one’s own planting and consumption, with a significant variety of vegetables and greens and the patients assist in its maintenance
Areas suitable for physical activities like physiotherapy and going for walks	<b>[Partly addressed]</b>	No physiotherapy activities are carried out in the green area, although the patients are encouraged to go for walks
Interactions of the patients through taking care of garden species	<b>[Partly addressed]</b>	The patients with only slight cognitive impairment help in looking after the garden, although this activity does not form a part of a program of sensory therapy
Gathering species for manual activities	<b>[Partly addressed]</b>	The manual activities regarding the care of vegetable species involve horticulture and picking flowers to decorate the indoor environments

Source: the authors.

The activities involving horticulture are essential to enable the residents to live in the midst of nature, work out or socialize. Horticultural activities can be shaped as a strategy for the evocation of affective memories by the patients.

In the case of activities carried out in the open air, these are mainly devoted to walking and enjoying the views. The scope of these should be broadened by integrating the physiotherapy activities in the green area. As well as having a closer contact with nature, interaction between the patients and health carers can be strengthened through physical activities carried out in the garden.

Moreover, as well as horticulture, there are patients who can help look after the vegetable species that are found in the garden. This dynamic does not form a part of the planning of activities that can be carried out by the patients but depend on the curiosity and wishes of the residents. This means the gardening activities are mainly concentrated on the kitchen garden, apart from picking flowers in the garden which is done by the patients with the assistance of the staff of health carers at particular times of the year, with the aim of making floral arrangements for decorating the rooms for indoor events. It is a very good idea to include a schedule of everyday activities for the residents with the aim of broadening the range of sensorimotor and cognitive stimuli

for the patients. These might involve both looking after the garden and gathering species for use in manual activities.

(e) **The Feeling of Comfort Provided by the Garden**

According to Hernández [35], the recommendations for the ‘Comfort’ category include the following: (20) location of seats that can allow the patients to rest. “Layout” which involves deciding which spots are suitable for rest; (21) the existence of seats and shade for periods after midday. In this context there are some new benefits that arose from the field study: (22) recreation rooms for the patients with a view of the garden, as in the following chart (Table 6):

**Table 6.** Scope of recommendations for the ‘Comfort’ category.

Comfort	Results	Comments
Location of seats where patients can rest. Layout which involves deciding which spots are suitable for rest	[Fully addressed]	There are fixed benches in the green area
Existence of seats and shade for periods after midday	[Fully addressed]	There is a square with ample shade the whole day
Recreation rooms for patients with a view of the garden	[Fully addressed]	The recreation rooms of the two wards are arranged so that they are open to the green area

Source: the authors.

In the case of both the horticultural activities and the walks, it is essential for the patient to be able to decide to remain in the green area and feel comfortable, as allowed by the presence of suitable seats in spaces of this kind. As well as the patients, the families and staff of carers can also benefit from the opportunities of social interaction and rest provided by these seats.

However, just having seats is not enough to ensure that the patients can remain in the outside area in a state of comfort. Patients with Alzheimer’s disease gradually lose any idea of temperature and for this reason, cannot remain directly exposed to the sun, especially in the period after midday. This means that during the season of the year when the sun is really hot, there must be areas with shade in the garden to ensure their well being.

With regard to the recreation rooms, owing to storms and sudden changes of weather, at times, it is impossible for patients or the staff of health carers to be in direct contact with the garden. At these times, the inside environment of the recreation room allows the patients to have an idea of the changes of weather throughout the day.

(f) **Plantations and the Sensory Stimuli Fostered by the Garden**

With regard to the ‘Plantation/Sensory Stimulation’ the recommendations of Marcus and Sachs [29] and Hernández [35] take account of the following: (23) the existence of plants with shapes/aromas that can provoke irritability; (24) plants that show signs of changes in their shape during the seasons – seasonal plantations;



(25) plants and flowers with vivid colors. At the same time, the findings of the research field include: (26) popular species that can be included in the planting carried out in the residential gardens; (27) species that can be found by the patients to stimulate touch, smell and vision, as shown in the chart below (Table 7):

**Table 7.** Scope of recommendations for the ‘Plantation/Sensory Stimulation’ category.

Plantation/sensory stimulation	Results	Comments
Existence of plants with shapes/aromas that can provoke irritability	<b>[Fully addressed]</b>	There are no plants that act as a trigger for irritability
Plants that show signs of changes in their shape during the seasons – seasonal plantations	<b>[Not addressed]</b>	Homogeneous plantations, which do not recognize the value of species that change with the seasons and the changes in the shape of the garden caused by them
Plants and flowers with vivid colors	<b>[Partly addressed]</b>	The configuration of the garden is predominantly green
Popular species that can be included in the planting carried out in the residential gardens	<b>[Fully addressed]</b>	There are species that are well-known by the patients such as bromelias, orchids, ferns and palm trees, as well as the vegetables and greens planted in the kitchen garden
Species that can be found by the patients to stimulate touch, smell and vision	<b>[Partly addressed]</b>	Patients can access all existing species. However, low diversity of species capable of stimulating patients’ sight and smell is identified

Source: the authors.

The species used in the plantation of the therapeutic garden are often employed in gardens and for the decorations of residential dwellings. This arouses a feeling of familiarity in the residents and enables them to evoke affective memories from their interaction with the plants and at the same time, avoid provoking irritability.

As well as the affective memory, the question of the perseverance of the sensory stimuli is an essential factor in the stimulation of the neural activities of patients with Alzheimer’s disease.

The landscape design project of the ‘Recanto Monsenhor Albino’ rest home benefits the tactile stimulus. This means the sense of vision and smell are less stimulated by the therapeutic garden.

Thus, what is recommended as a stimulus to vision is a heterogeneous plantation where there are striking alterations between the different seasons of the year. For example, azaleas, carnations and begonias are resistant to wintry conditions, while dahlias, geraniums and periwinkles are resistant to the high temperatures of summer. In addition, the planting of flowers and shrubs can attract the attention of the patients

because of their colors and striking presence such as roses, dracaenas [female dragons] and crotons.

And to stimulate the sense of smell, plants and flowers should be planted that exhale strong aromatic scents, such as lavender, roses, jasmine at night and dama da noite [lady of the night].

**(g) Stimuli Triggered by Features Found in the Garden**

With regard to the ‘Space/Stimuli’ category, Zeisel [6–9] and Marcus and Sachs [29] make the following recommendations: (28) architectural features which can stimulate the brain and behavior; (29) features that form the landscape of the garden and reflect the cultural traditions of the patients; (30) the shape of the plants, structures, shade, statues and so forth which can induce hallucinations or illusions, as set out in the following chart (Table 8):

**Table 8.** Scope of recommendations for the ‘Space/Stimuli’ category.

Space/stimuli	Results	Comments
Architectural features that can stimulate the brain and behavior	<b>[Not addressed]</b>	There are few features that stimulate the brain and behavior of the patients. The landscape proves to be monotonous and pastoral
Features that comprise the landscape of the garden and reflect the cultural traditions of the patients	<b>[Partly addressed]</b>	The grotto with the religious image represents an important cultural feature for the patients
Shape of plants, structures, shade, statues and so forth which can induce hallucinations or illusions	<b>[Fully addressed]</b>	There are no features that can provoke irritability

Source: the authors.

The architecture together with the landscape design of the ‘Recanto Monsenhor Albino’ rest home, endow the landscape with local features that are pastoral and monotonous. These features confine the inducement of key stimuli to the sensorimotor and cognitive system of patients suffering from Alzheimer’s disease. In view of this, it is recommended that new features should be included in the landscape that are able to induce positive stimuli to the brain and behavior of the residents, while taking account of the different stages of the disease.

The cultural link with space is another essential factor for the evocation of the affective memories of the patients [8]. The grotto with a religious image carries out in isolation the role of representing a cultural feature that is important for the residents and hence acts as a “trigger” for activating memories. In light of these benefits, more features should be included in the landscape of the garden that are closely linked to the cultural traditions of the patients.

Thus the architecture and landscape design project can provide positive stimuli to the individual. At the same time, there might be features or configurations that can act as “triggers” that can provoke irritability and stress or even hallucinations and illusions

in patients with Alzheimer’s disease such as shapes, noises, shadows, labyrinthian paths, and unclear access among other factors. When necessary, it is essential to detect these features so that they can be immediately removed.

**(h) Safety Features and the Preservation of the Garden**

With regard to the ‘Safety and Conservation’ category, the recommendations of Zeisel [6–9]; Marcus and Sachs [29]; and Pappas [31] are as follows: (31) the presence of emergency exits; (32) the perimeter fence of the garden should be visible to the patients; (33) the garden should be made visible from within the building; (34) checking the existence of poisonous plants; (35) checking the existence of species with sharp edges that can injure the patients. Thus the contributions made to the field include: (36) handrails to assist the patients when walking in the green areas; (37) a direct link of the inside environment with the garden; (38) maintenance of the garden, as follows (Table 9):

**Table 9.** The scope of the recommendations for the project in the ‘Safety and Conservation’ category.

Security and conservation	Results	Comments
Presence of emergency exits	<b>[Not addressed]</b>	There were no emergency exits
Ensuring the perimeter fence of the garden is visible to the patients	<b>[Partly addressed]</b>	The landscape is extensive and the residents may have difficulty in knowing the garden in its entirety
The visualization of the garden from inside the building	<b>[Fully addressed]</b>	The garden can be seen from all sides of the outbuildings
Existence of poisonous plants	<b>[Fully addressed]</b>	There are no poisonous plants
Existence of plants with sharp edges that can injure the patients	<b>[Partly addressed]</b>	There are plant species such as agave and Phoenix palm trees that can injure the face or hands of the patients
Handrails to assist the patients when walking in the green areas	<b>[Partly addressed]</b>	There are handrails on the walkways that pass through the green areas; however, they do not give assistance for walking by the grass verges
Direct link of the inside environment with the garden	<b>[Fully addressed]</b>	The entrances to the wings and huts are directly connected to the green areas
Maintenance of the garden	<b>[Fully addressed]</b>	There is a team of gardeners who carry out maintenance on a daily basis

Source: the authors.

The emergency exits are not properly signposted. As well as following correct safety standards, the emergency exits must be visible and accessible. However, they should not contrast with the atmosphere of the landscape to avoid causing “triggering effects” and agitating the patients.

It is essential to know the landscape in its totality to prevent the patients sounding out places that are unauthorized or inaccessible. Similarly, it is essential for the residents to be able to see the garden as a whole so that their walks are not the cause of stress, anxiety or uncertainty [44].

Since the space of the clinic is pervaded by a green area, it is recommended that mobile grab bars should be made available so that they can be used in the gardens during walks, physical activities and visits from the families.

In the clinic, the garden can be seen from all sides of the huts. The entrances of the wards and huts are directly connected to the green areas. All the men's and women's bedrooms are open to the green areas too. These bedrooms have a small balcony where the patients can sunbathe without having to leave their apartments.

The lack of judgment that characterizes patients with Alzheimer [8], can lead to hazardous situations such as tasting and chewing poisonous plants. The daily maintenance of the green areas of the 'Recanto Monsenhor Albino' rest home ensures that there are no poisonous plants throughout the whole area, as well as helping to preserve the therapeutic garden in a good condition. However, to ensure the protection of the health of the residents, health carers and visitors, species of plants with sharp edges, such as agaves and Phoenix palm trees should be replaced with other plants since they might injure the face or hands of the patients.

## 6 Conclusions

This paper has sought to demonstrate the importance of the landscape design project as a means of assisting the non-pharmacological treatment of Alzheimer's disease. It is based on knowledge of neuroscience and the assistance that this research can provide in a created space. Studies devoted to neuroplasticity provide evidence of how someone's brain is closely linked to his/her surroundings and how the external stimuli caused by this environment can alter the brain structure. Thus the designed space is able to stimulate the brain capacity to interfere in the behavior of human beings.

Against this background, the landscape design project can be regarded as a key aspect of constructed space. The presence of green areas has proved to be significant during the whole process of transforming the individual-architecture relationship. In the environment required for healing, it acquires an even more significant value insofar as it combines both the treatment and therapeutical domains of the patients. This can make us fully aware of the relationship established by the landscape design project with human beings and the assistance that the planned green areas can offer to the non-pharmacological treatment of dementia such as Alzheimer's disease.

The results obtained here pinpoint 38 recommendations for the design of therapeutic gardens which are outlined here and divided into 8 basic categories: (a) access; (b) pathways; (c) uses; (d) particular activities; (e) comfort; (f) planting/sensory stimulation; (g) spaces/stimuli; (h) safety and conservation. Out of all the recommendations, 26 emerged from the research carried out by Zeisel [6–9]; Marcus and Sachs [29]; Pappas [31]; Hernández [35], which were discussed in the review of the literature; and 12 originated from the investigation conducted in the field study at the 'Recanto Monsenhor Albino' rest home. 18 of the recommendations were fully addressed; 15

partly addressed and 5 not addressed at all. In other words, almost 53% of the requirements either needed to be reinforced or fully implemented.

On the basis of these results, it can be inferred that the official recommendations for the design of therapeutical gardens aimed at the non-pharmacological treatment of Alzheimer's disease have been of significant value. They can be represented to healthcare centers treating patients with this illness, particularly since they provide clear guidelines and increase the range of sensorimotor and cognitive stimuli to help improve the well being and quality of life of the residents.

In future developments, the research will broaden the scope of the investigation in the field and examine other clinics in the State of Sao Paulo (Brazil), that are dedicated to caring for patients with Alzheimer's disease. The aim of this is to extend the current set of recommendations based on the landscape design project to other centers of this nature and make further contributions to these patients.

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