Architecture-Neuroscience Cooperation: Project Recommendations to Therapeutic Gardens Design for the Non-pharmacological Treatment of Individuals with Alzheimer's Disease

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Abstract. The Neuroscience-Architecture cooperation indicates the potentiality of the built space in molding and shaping the structure of the brain and, consequentially, impacting and transforming the human behavior. Such potentiality is supported by the concept of neuroplasticity. Changes in the structure of the brain can also be verified in individuals with neurological degenerative diseases, such as Alzheimer's disease. Nowadays, the number of diagnostics of the disease is over 47 million cases all over the globe. Its treatment is based on pharmacological and non-pharmacological procedures. The pharmacological consists of medication administration to the patient whereas the non-pharmacological encompasses a set of cognitive, sensorimotor, and somatosensory stimuli directed to minimizing symptoms and postponing the advance of the disease. Considering the latter, the present research brings several contributions, discussing and proposing 45 project recommendations to the landscape design of therapeutic gardens, integrating the scope of non-pharmacological treatments of Alzheimer. From the analysis of two Brazilian clinics dedicated to the care of these patients, the research points out vulnerabilities and capacities of their respective projects, aiming at the promotion of a better life quality, wellness and conviviality for the residents of these spaces.

Keywords: Landscape design · Neuroscience · Alzheimer's disease · Therapeutic gardens · Guidelines on design

1 Introduction

Researches concerning the Architecture-Neuroscience cooperation [1–6] indicate potentialities of the built space to promote a significant set of stimuli on the human brain. Such a statement also discloses a new understanding, suggesting that such stimuli, coming from the environment where the individual is placed, are able to impact and influence the behavior. By being constantly stimulated, the brain reacts to those stimuli. And this set of neural reactions through time models and shapes the very

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structure of the brain, changing it. Thus, these changes are applied to human behavior and how one experiences the space and develops his or her activities [6].

The capacity of the brain to adapt and to be molded, both in its structure and the functions performed by the nervous system, is called "neuroplasticity" [2, 7, 8]. It happens all through the human being formation period and also through adult life. Those changes on the brain structure can also be verified in individuals with degenerative neurological diseases, such as the Alzheimer's disease.

Alzheimer is a neurological progressive disease, characterized by the gradual impairment of cognitive and motor functions. Nowadays, the number of diagnosed cases reaches 47 million people all over the world, being one million of them in Brazil. The treatment is based on pharmacological and non-pharmacological procedures. The pharmacological consists of medication administration to the patient whereas the non-pharmacological encompasses a set of cognitive, sensory-motor, and somatosensory stimuli directed to minimizing symptoms and postponing the advance of the disease. In this scope, the contributions of living and staying in green areas are noteworthy, especially when associated with walking, light physical exercises, among many other activities that provide positive experiences to the patient's emotional state and health.

The beneficial relations that individuals develop with nature are anchored to the concept of "*biophilia*", which indicates the connection between human beings and nature as intrinsic and perennial through all their existence. The human beings have their origins bonded to nature, and they need nature to survive. In other words, the individual is biologically prepared to feel safe and comfortable in natural environments and spaces projected with green areas [10].

Ulrich [10] proposes that human beings develop their aesthetic standards from their memories related to nature. These memories have an emotional character and are essential to the understanding of human behavior. Such memories, which refer individuals to their own subjective universe, are called "affective memories". They can be evoked by scents, flavors, sounds, textures, colors, landscapes, that is to say, through a whole range of mental images formed in the brain, which are associated with moments of high emotional value to the individual. The immediate result of these memories is temporary changes in the body state that can induce it to wellness [11].

In this context, and considering the scope of architecture, we can assess the fundamental role that the landscaping project plays in the configuration of green areas, especially in the project of therapeutic gardens dedicated to the care of patients with neurological degenerative diseases, such as Alzheimer. With the objective of bringing significant contributions to the progress of this investigation area, this paper proposes and discusses 45 recommendations to landscaping projects of therapeutic gardens in clinics for treatment of people with Alzheimer's disease. In this scope, we point out the vulnerabilities and potentialities of these projects, in order to provide better life quality, wellness and living to the residents of these places.

2 Methodology

Literature [3, 13–18] presents a series of recommendations concerning the consistent configuration of therapeutic facilities and care procedures to patients with Alzheimer. Taking these references as a starting point, this research conducts field investigations of the green areas of two clinics dedicated to the care of patients with Alzheimer's disease in Brazil. The first is located in the city of Campinas, and the second in the city of Catanduva, both in the interior of the State of Sao Paulo. In the picture below, the color green represents the amount of green area present in both clinics (Fig. 1).

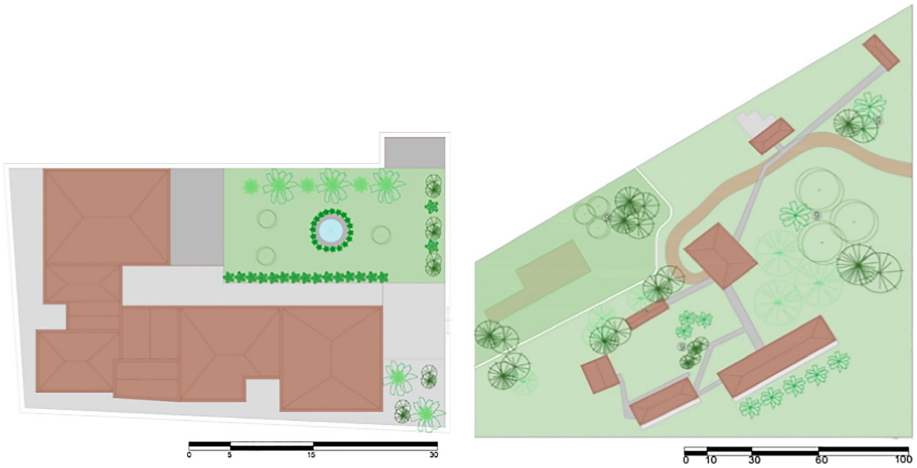

Fig. 1. Schematic Design of SeniorVit (left) and Recanto Monsenhor Albino (right). Source: Authors (Color figure online)

Investigations took place between August 2017 and December 2018. The collection of references from scientific literature along with the results obtained through field investigations configure the scope of project recommendations and parameters, through which the green areas of both clinics were evaluated. This frame of recommendations is structured by eight categories: (a) accesses; (b) specific activities; (c) pathways; (d) comfort; (e) spaces/stimuli; (f) planting/sensory stimulus; (g) safety and conservation; (h) uses.

3 Results and Discussions

From the studies of the facilities and the green areas present on both clinics, we further present the eight parameters applied in this analysis as well as the results and discussions. In the tables below, the green fields of the column "project recommendation" indicate contributions proposed by the authors of this paper whereas the white fields represent contributions coming from the literature:

(a) Accesses

Considering the element "Access", the clinic SeniorVit fully complies with five project recommendations and partially complies with one. The second clinic, Recanto Monsenhor Albino fully complies with four recommendations, and partially with two among the six comprising this category. In sequence, we discuss the respective results.

The "Number of doors allowing direct access to the garden" must be limited, considering that in the second stage of the Alzheimer's disease patients can be confused when more than one pathway is presented. The repetition of activities (such as visits to the garden) stimulates the patients' cognitive functions, and accessing these activities through a single pathway minimizes potential exhaustion due to spatial disorientation. Regarding this aspect, both clinics partially comply with the aforementioned parameter. SeniorVit, by providing two accesses to the garden, reinforces the residents' spatial disorientation, because their chances of becoming confused when deciding which way to go are increased. In its turn, Recanto Monsenhor Albino also reinforces the patients' spatial disorientation by separating the building wings according to gender (male/female), increasing the chances of the patients becoming confused when returning to their respective wing.

The number of "bathrooms placed near the garden" must be proportional to the number of patients, and these installations must also be visible and near the green area. This need is due to the urinary incontinence to which these patients are susceptible in the second stage of the disease [3]. As for this parameter, SeniorVit fully complies with it, providing two bathrooms close to the garden. In its turn, Recanto Monsenhor Albino places both bathrooms in a distant place from the green area; considering that this area comprises all the terrain of the clinic, such placement makes it impossible for residents to see the bathrooms when they develop activities there. It is recommended the placement of bathrooms on the green area for the patients and the clinic's staff.

The "freedom of access to the garden" is essential, especially in the first stage of the disease, as it stimulates the patients' autonomy, their cognitive functions, and slows the progress of short term memory loss. In contrast, patients with high cognitive impairment should not remain in the gardens without supervision of team members, so locking the doors is important to avoid situations whose may represent risks to these patients. Besides that, "ease of access to the garden" fosters the feeling of safety and helps patients with their spatial orientation. Both parameters are fully and accordingly accomplished by the two clinics. SeniorVit's garden can be seen through the living room and the annex building, and the green area is available to the patients and the care staff all through the day and sometimes at night. This usage availability promotes the presence and living in the garden. In the case of Recanto Monsenhor Albino, the green area surrounds all the buildings, allowing patients to have direct contact with the garden all over the area between sheds. Beyond promoting conviviality among patients in this area, the easy access to the garden also reinforces their biophilic connection with nature.

As for the "accessibility" parameter, not only it is demanded by law[1], but it is also indispensable to the patients' safe and comfortable mobility. Both clinics are in full

[1] Further information about NBR9050 available in: https://goo.gl/S7veFJ.

compliance with it, as they provide: sidebars on the walls to assist locomotion; non-slip flooring; proper terrain relief for waking; ramps with proper inclination; and absence of obstacles or steps impeding access to the green area (Table 1).

Table 1. Scope of recommendations in the category "Accesses". Source: Authors.

Project Recommendation	SeniorVit Clinic	Recanto Monsenhor Albino
Number of doors allowing direct access to the garden	**[Partially accomplished]**. Two accesses to the Garden: living room and suite's hallway can cause spatial disorientation.	**[Partially accomplished]**. There is one exit per wing (male and female). Due to this separation, patients can feel confused when out of their wings.
Bathrooms placed near the garden	**[Fully accomplished]**. Two indoor bathrooms near the garden.	**[Partially accomplished]** Sheds offer bathrooms, but they are far from the green area.
Freedom of access to the Garden due to locked doors during the day	**[Fully accomplished]**. Doors are kept open during the day for patients in the first stage of the disease.	**[Fully accomplished]**. The doors of both wings are kept open during the day for patients in the first stage of the disease.
Ease of access to the Garden by patients	**[Fully accomplished]**. Accesses are kept open during the day under the supervision of nurses.	**[Fully accomplished]**. The configuration of the clinic allows easy access to the green area.
Accessibility	**[Fully accomplished]**. Ramps and handrails are available in the accesses.	**[Fully accomplished]**. Ramps and handrails are present in all the accesses.
Internal pathways leading to the garden	**[Fully accomplished]**. Hallway in the dorm area with direct access to the garden.	**[Fully accomplished]**. Every internal pathway has a connection to the garden, as the green area surrounds both wings.

(b) Specific Activities

Regarding the element "specific activities", SeniorVit Clinic fully complies with four project recommendations and partially complies with one of them, whereas Recanto Monsenhor Albino fully accomplishes one recommendation and partially with the remaining four. The respective results are shown below.

The "areas for manual activities" are extremely relevant to the patients' routine. The stimuli from these activities promote the increase of vitamin D production by the organism; strengthen the conviviality among patients and the care staff; and promote neuroplasticity and cognition through the somatosensory perception of different textures, scents and flavors during the recognition of species from the garden.

Regarding this issue, as SeniorVit provides a smaller green area, its usage potential for these activities is limited. In contrast, the extent of terrain used as green area in Recanto Monsenhor Albino, which is comparable to a farm, allows the planting of a wide range of species and manual activities.

As it is important for the residents to have an area to develop manual activities, it is also indispensable that they have the "opportunity to exercise in green areas". Walking, physiotherapy, stretching and other light physical activities allow the patients to keep their bodies active, preventing the risk of exhaustion related diseases. Besides that, they are closely related to the stimuli the body can provide to the brain, for example, the liberation of hormones such as endorphin, and the absorption of vitamin D by the contact with sunlight. Furthermore, being in open areas helps patients to acknowledge the different hours of the day, and to sense temperature, sounds, and the wind, which also aids the maintenance of their circadian rhythms. In SeniorVit, patients are encouraged to use the garden area and constantly develop light physical activities. In Recanto Monsenhor Albino, since the second half of 2018 patients can make use of a new small square with concrete floor and outdoor gym equipments, installed in front of the Friendship Square. However, this area has no roof, and in periods of high temperatures the iron-made equipments heat up, which can harm patients. Moreover, despite the wide green area of the clinic, patients have indoor physiotherapy sessions.

The "interaction with species and garden caring" and the "harvesting for use in manual activities" also strengthen conviviality among patients and between them and the care staff. But these activities also provide other results: they stimulate the sensorial motor system of the patients; and exercise cognition through the perception of colors, scents, flavors, and textures. Planting and harvesting, while involving patients in the life cycle of species, promote the memorization of seasons. SeniorVit, despite its reduced green area with a low diversity of fruit species, reinforces the patients' contact with the vegetable garden and encourages harvesting for manual activities. Recanto Monsenhor Albino, in its turn, has horticulture as part of its therapies along with the harvesting of species for decoration. However, these activities are performed only by patients on the first stage of the disease.

The "daily time for patients to interact in the green area" shows the importance of routine in the life of patients with recent and long term memory loss. Through repetitive activities performed always at a particular time, their cognition is exercised [19]. In its time schedule, SeniorVit considers visitations and a daily program of activities and conviviality at the garden, while Recanto Monsenhor Albino does not establish a routine for patients to enjoy the area of the gardens. Here, it was verified only the incentive for walking in the morning (Table 2).

Table 2. Scope of recommendations in the category "Specific activities". Source: Authors.

Project Recommendation	SeniorVit Clinic	Recanto Monsenhor Albino
Areas for manual activities involving horticulture and soil managing	**[Partially Accomplished].** There is a vegetable garden, but not an expressive amount of fruit species. Patients are encouraged to participate in the cultivation.	**[Fully accomplished]**. There is a huge vegetable garden for planting and internal consumption and a wide variety of vegetables and greenery, which are cultivated with the help of patients.
Suitable areas for physical activities, such as physiotherapy and walks	**[Fully accomplished]**. The garden arrangement is suited for the care staff to develop physical activities with the patients.	**[Partially accomplished].** Square with gym equipments used by patients in the first stage of the disease. Physical therapy takes place indoors.
Patient interaction with species and garden caring	**[Fully accomplished]**. Patients have contact with the Garden on a daily basis and are encouraged to take care of the species.	**[Partially accomplished].** Patients with light cognitive impairment help to take care of the garden, however, this activity is not part of a sensory therapy program.
Harvesting species for use in manual activities	**[Fully accomplished]**. Patients are encouraged to harvest species and perform manual activities with them, such as producing paintings, bouquets, and collages	**[Partially accomplished].** Manual activities involving growing vegetable species comprehend horticulture and flower harvesting for indoor decoration, undertaken only by patients in the first stage of the disease.
Daily time for patients to interact in the green area	**[Fully accomplished]**. Patients interact with the green area on a daily basis, usually at the same time in the mornings and afternoons. They are also free to enjoy the area when not performing scheduled activities.	**[Partially accomplished].** Mornings are the only period for using the green area, which occurs on walks, which have no specific time.

(c) Pathways

Considering the element "pathways", among the five project recommendations of this category, both clinics fully comply with two of them. In contrast, the remaining three are partially accomplished by Recanto Monsenhor Albino whereas SeniorVit partially accomplishes one of them, leaving the other two unaccomplished. The results are presented below.

The "route complexity" and the "route suggested by floor planning and design" are key characteristics for patients' autonomy. Less complex pathways provide more favorable conditions for patients to orient themselves on space. In this sense, "floor planning and design" should guide patients through the routes they have to take, minimizing their chances to get lost. Even in small areas, floor planning and design is essential. In both clinics, pathways are not fully defined. There is no route suggested by floor planning and design in the green area of SeniorVit. On the other hand, in Recanto

Monsenhor Albino, particularly in the wing connection area, there is a planned floor, handrails and roof, which indicate the path connecting the wings. Both clinics have elements on the landscape that serve as "marks for the orientation of the patients on their routes". SeniorVit has a water fountain in the middle of the garden, while Recanto Monsenhor Albino has huge species of palm trees, furniture disposed on the green area and a grotto with the image of Blessed Virgin Mary. This grotto is not only a hallmark of the garden's landscape but is also of extreme importance for almost every resident and staff member, since Catholicism is predominant in the region's culture. Therefore, habits involving the practice of faith, such as prayers and image contemplation, can be done at this grotto. These subjective practices evoke affective memories of patients, being closely connected to emotions and personal experiences of the individuals. According to Damásio [20], everything an individual experiences (feels) or manifests (expresses) through emotions has an affective character. Thus, personal memories of religious activities performed in other contexts than the clinics have the potential to bring positive feelings and emotions in the patients and also to connect them to their faith.

The "smooth topography" is crucial to the comfort and safety of patients. The smooth grounds ups and down can help strengthen the leg muscles, as well as the performance of aerobic exercise and breathing control. Both clinics are in full compliance with this project recommendation, as their green areas are set on a flat topography. In SeniorVit this area is completely flat, with just one access needing a ramp. Meanwhile, Recanto Monsenhor Albino has minor irregularities in its space, which do not impact the natural topography of the terrain at all.

The recommendation "pathways that protect patients from bad weather" comprehends the importance of protecting patients from hostile conditions. As individuals with Alzheimer progressively lose their motor abilities and sensibility, they also lose the capacity to distinguish between very high or low temperatures, becoming incapable of protecting themselves from harsh weather conditions. Because of that, green areas and outdoor places must provide protection to residents. SeniorVit has no cover on the garden area. Only the annex has it, but this building is actually located beside the green area. The pathways of Recanto Monsenhor Albino are protected with roofs made of polyvinyl chloride lining (better known as PVC). This material is widely used in linings because of its capacity to resist bad weather conditions and also due to its thermal insulation quality. With the aid of trees, the roofs produce effective shadows for the protection of patients along the pathways. However, in windy or rainy days, the roof is not quite effective, as the sides of the pathways are not protected (Table 3).

Table 3. Scope of recommendations in the category "Pathways". Source: Authors

Project Recommendation	SeniorVit Clinic	Recanto Monsenhor Albino
Route complexity for patients	**[Partially accomplished].** Open space with no defined route, no complexity at all.	**[Partially accomplished].** Pathways are marked with different floor tiles; roof covers and handrails are only noted in the wings connection area.
Landscape marks and attention-grabbing elements on the patients' pathways	**[Fully accomplished].** There is a water fountain in the middle of the garden. Three huge tree species configure distinctive marks.	**[Fully accomplished].** Some marks are noted: a grotto with the image of Our Lady of Aparecida; tall vegetable species stand out in the area.
A route is suggested by floor planning and design	**[Not accomplished].** There is no floor planning and design suggesting a particular route.	**[Fully accomplished].** The entire route is specifically planned and designed.
Smooth topography for the patients' walks and permanence	**[Fully accomplished].** Plain topography all over the garden area.	**[Fully accomplished].** The terrain is plain enough to be comfortable for the patients.
Pathways that protect patients from bad weather	**[Not accomplished].** The green area has no cover at all.	**[Partially accomplished].** Pathways are protected by a roof cover, however, its dimension is not appropriate in cases of strong winds and rain.

(d) Comfort

In what regards the parameter "comfort", Recanto Monsenhor Albino fully accomplishes six of the project recommendations, while one is not accomplished. SeniorVit fully accomplishes three recommendations, partially accomplishes another three, and does not accomplish one. The results are as follows:

The "presence of furniture for the resting of patients and their families", as well as "shadows after midday" are vital to the comfort and conviviality on the green area. Individuals with Alzheimer require such cares since their skin sensibility is intensified through their lives and, consequently, the risks of being exposed to high or low temperatures increase [3]. Regarding this topic, Recanto Monsenhor Albino is in compliance with such requirements, providing a square with furniture and a large area with shadows. SeniorVit, on the other hand, provides furniture in the annex, which functions as an extension of the garden, even though it is not located in the green area.

Both clinics have "indoor environments with a direct view of the garden". In SeniorVit, one can see the garden through the living room whereas in Recanto Monsenhor Albino the landscape can be seen through the windows of every wing. This view, which comprehends aspects of nature, is essential for the patient to have the perception and notion of time: if it is night or day, raining or not, if the garden is like the day before or if something has changed in it. This observation exercise stimulates the patients' brain and assists their cognitive processes [21]. Such a connection between indoor spaces and the gardens stimulates the connection that patients establish with the green area, which can be appreciated even in days or periods when actually staying on the garden is not possible. The link between built spaces and nature brings

several benefits to human beings, bringing them close to a primitive, biophilic relation with nature. When added to a built space, nature elements can induce positive cognitive and emotional changes, reduce expressively the stress level of individuals, promote wellness and benefit their health [17].

The recommendation "orientations of predominant winds in the region" speaks of the condition of the clinics' territories and the relation of this placement with the comfort of the patient in open and outdoor areas. Besides that, the exchange of air in areas next to the gardens is necessary, because it provides better temperature conditions and promotes the hygiene of spaces through air renovation. SeniorVit has the configuration of a residence, with barriers against the strong winds of the region of Campinas (Sao Paulo), coming mainly from the southeast. But these barriers do not affect the exchange of air or the health conditions of the space where the annex building is. As for the territory of Recanto Monsenhor Albino, it is affected by slow speed winds coming mainly from the east. The clinic topography and its ranch configuration, so to speak, do not create barriers for the wind flow. However, winds are welcome in the area, as they reduce the heat sensation due to the high temperatures of the region of Catanduva (Sao Paulo).

The presence of the element "water" in the garden is quite desirable. Not only this element is necessary for the survival of all species, but it also improves the relative humidity in periods of dry weather, preserves more pleasant temperatures in hot days, and also becomes part of the environment natural landscape, acting as a somatosensory stimulus and promoting wellness and comfort for individuals making use of the space. SeniorVit has a water fountain at the center of the garden. It works during the day and the water sound integrates the therapeutic activities performed at the garden. Considering the great benefit that the presence of water brings to the space and patients, it should be used more frequently and with different installations, like a small lake or cascades, referring to more natural configurations and becoming more related to the flora of the space. However, making further use of this element requires caution so that it does not represent a danger for the patients. For example, deep lakes or lakes with no protection borders should be avoided, as patients can become wet, get hurt or even drown.

Recanto Monsenhor Albino does not have any part of its landscape where the element "water" is used. Its bucolic configuration, wide space, and climatic characteristics make it propitious for the green area project to make use of this element.

As for "sounds external to the clinic that can disturb interaction" it is important to consider that strange or loud noises can frighten, irritate, and even disorient the patients. Individuals who have lost neurological functions tend to have difficulties in associating sounds, a task performed by the primary auditory cortex [22]. In contrast, pleasant and familial sounds stimulate cognition and promote the patients' wellness. SeniorVit, being located in an urban area, with many vehicles and people, does not fulfill this recommendation, because external sounds can easily disturb patients' interaction at the garden. Recanto Monsenhor Albino, on the other hand, fully accomplishes this recommendation, as it is located in a quiet and rural-like area, far from the urban environment. There, it is possible to hear the sounds of different animals, the wind blowing through leaves, and people talking, that is, the landscape (what is seen) is in perfect harmony with the sounds it produces. This harmony is quite beneficial for the patients because the primitive connection that human beings have with nature predisposes them to this association among senses.

Regarding "pleasant ambient temperature", it involves avoiding thermal conditions that can represent risks for the health of patients with Alzheimer, considering their progressive sensibility towards high and low temperatures throughout the disease [3]. Therefore, particular devices should be employed in the project of the space in order to keep it with adequate temperatures for sensible patients. In this sense, SeniorVit makes use of elements such as a water fountain, grass designed floor, ceramic floor, and visible roof cover on the annex building. Recanto Monsenhor Albino, in its turn, has living areas with shadows; huge treetops, which help to stabilize the temperature; grass floor, which absorbs heat; and the ceiling height of the buildings is low, allowing better ventilation (Table 4).

Table 4. Scope of recommendation in the category "Comfort". Source: Authors.

Project Recommendation	SeniorVit Clinic	Recanto Monsenhor Albino
Presence of furniture for the resting of patients. Layout suggesting places to stay	**[Partially accomplished].** Furniture is present on the annex building and barbecue areas. No permanent furniture is present in the grass area.	**[Fully accomplished].** There are permanent benches in the green area.
Sun Trajectory X Staying area layout	**[Partially accomplished].** Seats are available only on the roof covered areas (annex building/barbecue area).	**[Fully accomplished].** There is a square with plenty of shadows. Where sunlight is excessive, there is no staying layout.
Living room for patients with a direct view of the garden	**[Fully accomplished].** The living room (indoor environment) offers a direct view of the garden.	**[Fully accomplished].** The living room of both wings has openings for the green areas.
Orientation of predominant winds in the region	**[Fully accomplished].** The wind comes, especially from the southeast. The clinic's building appropriately blocks strong winds without making the environment unhealthy.	**[Fully accomplished].** Low-speed winds, predominantly from the east. The low speed of the winds allied with the topography of the region produces a pleasant climate for the patients.
Presence of the element "water" in the composition of the garden	**[Partially accomplished].** There is a water fountain in the garden.	**[Not accomplished].** There is no water in the green area.
Sounds external to the clinic that can disturb interaction	**[Not accomplished].** The clinic is set on an urban area among residences and stores, close to the street.	**[Fully accomplished].** The clinic is located in an area far from the city, so it has pleasant ambient sounds, as birds and animals. Loud noises or cars are not heard.
Pleasant environment temperature	**[Fully accomplished].** The elements of the area favor a stable mild temperature.	**[Fully accomplished].** The elements of the area favor a stable mild temperature.

(e) Spaces/Stimuli

As for the element "spaces and stimuli", it is comprised of three project recommendations. SeniorVit fully accomplishes two and partially one of them. Recanto

Monsenhor Albino fully accomplishes one, partially another one, but does not accomplish a third one. The results are as follows.

For the "patient's brain to be constantly stimulated by the built space", there must be elements in it offering the patients recollections or at least bringing them something familiar. Therefore, architectonical elements have a powerful role in activating the individual's memory and cognition [2]. "Elements that establish a connection with the history and culture of patients" can also increase this contribution. By stimulating the recollection of affective memories and an immediate and intense identification of the individual with the space, these elements also reinforce the feelings of belonging and promote the appropriation of the place, which brings positive emotions on individuals with neurological dysfunctions [3]. In this category, SeniorVit presents consistent results, as its garden has vegetable species familiar to the patients, positively stimulating their brains and behaviors through the colors, forms, sizes and diverse textures of these vegetables. In contrast, the bucolic, almost tedious landscape of Recanto Monsenhor Albino does not offer diverse sensorial stimuli to its patients capable of activating their memories and bring recollections. In this scenario, only the grotto with the image of Blessed Virgin Mary establishes a relation with a cultural aspect of most of the patients (about 90% of them are Catholic).

The "form of architectural elements or the disposal of vegetable species in the garden can trigger hallucinations or patients' irritability". Such possibility directly influences the safety of individuals on the green areas, affecting their autonomy and confidence. That is, the projection of shapes and shadows can frighten or even traumatize them in severe cases. Regarding this issue, both clinics arrange their green areas favoring contemplation and a welcoming and safety feeling for their residents, with no information capable of negatively interfering in their experiences and interactions (Table 5).

Table 5. Scope of recommendations in the category "Spaces/Stimuli". Source: Authors.

Project Recommendation	SeniorVit Clinic	Recanto Monsenhor Albino
Architectonic elements that stimulate the brain and positive behaviors	**[Fully accomplished].** Presence of different and familiar vegetable species to the patients	**[Not accomplished].** Few elements stimulate the brain. Monotonous landscape.
Elements composing the garden landscape relate to the cultural life history of patients	**[Partially accomplished].** Besides the regular species of the region, already familiar to the patients, there are no other elements related to their culture or life history.	**[Partially [accomplished].** Only the grotto with a religious image represents an important cultural element for the patients.
Avoiding plants, structures, shadows, statues and other architectural elements with forms that can trigger hallucinations or illusions	**[Fully accomplished].** The structure of the garden is wide, without compromising shadows created by the covers or trees.	**[Fully accomplished].** No elements work as trigger elements for irritability

(f) Planting/Sensorial Stimulus

The element "planting and sensorial stimuli" comprises six project recommendations. Among these, SeniorVit fully accomplishes three, however, the other three are not applied. Recanto Monsenhor Albino fully accomplishes two, partially another two, and the remaining two are not accomplished. The results and discussions are as follows:

Just as the form and configuration of the built space can affect how patients stay in the green area, the vegetable species chosen for the landscaping project can also produce positive or negative effects on them. That is why it is crucial to avoid using "plants with shapes that can trigger irritability". Considering that, both clinics are in full compliance with what is recommended. Both gardens present traditional species from the Brazilian fauna, such as palm trees, bromeliads, trumpet trees, cerimans (*Monstera deliciosa*), pacovás (*Philonendrum martianum*), ferns, among others, which are familiar and from the local culture.

The planting of "species that evince seasonality" and "species with vibrant colors" are related and reflect the landscape's potential to be part of a patient's routine. For the individual with Alzheimer's disease, it is important to acknowledge the change of seasons and to feel different sensations caused by the alternation of the weather and temperatures. Such perception allows patients to understand the times of the year, be oriented within time and adjust their circadian rhythms [16]. In both clinics, plants show little or no seasonality at all, creating monotonous landscapes through most part of the year. Color vibrant species are seen in small amounts in Recanto Monsenhor Albino, nonetheless.

Concerning "popular species", they are expressive in both clinics and are the kind of plants that can be manipulated by patients, producing somatosensory stimuli, such as vegetable gardens, where patients with a higher level of cognitive preservation are encouraged to take part in planting and harvesting. Usually, individuals are willing to manipulate plants and flowers they already know. Besides that, handling familiar species helps patients to recollect affective memories. Species that were part of their lives or marked an important moment of their trajectories can evoke memories that bring positive emotions and feelings.

As for "plants and/or flowers with remarkable scents", researches about the potential of smell [23] show it as humans' most acute sense. In patients with reduced brain functions, stimulating this potential represents a significant form of delaying the loss of such functions. However, both clinics do not have plants and/or flowers that exhale remarkable scents. Species such as lavender (*Lavandula*), jasmine (*Jasminum*), gardenia (*Gardenia jasminoides*), "manacá-de-cheiro" (*Brunfelsia uniflora*), night-blooming jasmine (*Cestrum nocturnum*) could be incorporated to the landscaping project of the clinics, helping to promote the set of satisfactory somatosensory stimuli to patients (Table 6).

Table 6. Scope of recommendation in the category "Planting/Sensorial stimulus". Source: Authors.

Project Recommendation	SeniorVit Clinic	Recanto Monsenhor Albino
Plants with shapes/scents that can trigger irritability	**[Fully accomplished].** There are no exotic species or with shapes or scents that might stress patients	**[Fully accomplished].** None of the plants can trigger irritability
Plants that evinces changes according to the change of seasons. Seasonal planting	**[Not accomplished].** Homogeneous planting, that does not value the seasonality of species and the reconfiguration of the garden they could provide	**[Not accomplished].** Homogeneous planting, that does not value the seasonality of species and the reconfiguration of the garden they could provide
Plants and flowers with vibrant colors	**[Not accomplished].** No species with vibrant colors	**[Partially accomplished].** The garden setting is predominantly green, with few colorful species
Popular species that remind plants used in residences	**[Fully accomplished].** There are popular species, recognized by the patients, such as palm trees, orchids, calliopsis, and edible vegetables.	**[Fully accomplished].** There are familiar species for the patients, such as bromeliads, orchids, ferns, and palm trees, not to mention the greenery and vegetables from the vegetable garden.
Species that can be assessed by the patients, stimulating their touch, smell and vision	**[Fully accomplished].** Every species can be accessed by the patients.	**[Fully accomplished].** Every species can be accessed by the patients.
Plant and / or flowers with remarkable scents	**[Not accomplished].** There are no plants or flowers with remarkable scents.	**[Not accomplished].** There are no plants or flowers with remarkable scents.

(g) Safety and Conservation

Regarding the element "safety and conservation", from the seven projects recommendation to green areas, SeniorVit fully accomplishes five and partially two. Recanto Monsenhor Albino fully accomplishes three of the recommendations, leaving another three partially applied, and one not accomplished.

The "presence of emergency doors" is essential for the garden security, and is required by law[2]. Emergency exits should be indicated by signs, but they should not stand out excessively in the landscape, as they can cause agitation and curiosity in patients with Alzheimer [13]. SeniorVit has one emergency exit in the back of the garden, while the rural Recanto Monsenhor Albino, being similar to a farm, has a vast outdoor area with no buildings and closed with gates, but there is no emergency exit in the green area.

The "visibility of the entire garden perimeter" is also related to patients' safety. Besides that, comprehending all the extension of an area promotes individual autonomy [17]. For Albright [24] the environment must favor visual perception, thus more defined "neural maps" can be formed in the brain. These maps are called "wayfinding",

[2] Further information about NBR9077 available in: https://goo.gl/Zku1dJ.

and are related to the analysis of the space performed by the individual who lives in it. This spatial organization assures the proper visual perception and, consequently, allows individuals to locate themselves and wander around with no obstacles. Due to its neuroplasticity - that is, the brain's capacity to change its own structure - it is possible to infer the crucial role that the built space and the stimuli generated by it play on the neural architecture of the individual living in this place. From that, it is possible to identify a straight connection between the spatial configuration of a clinic and the behavior of its residents. In other words, the "visibility of the entire garden perimeter" has the potential to inhibit or intensify negative or positive stimuli and, therefore, provide greater autonomy or complete dependence of the patient.

As already mentioned, Recanto Monsenhor Albino encompasses a wide field, making it impossible to grasp at once all its green area. SeniorVit, on the other hand, is organized like a residence, allowing the observation of the garden as a whole from the living room and some of the residents' rooms.

There are no "toxic plants" in the clinics. This condition permits patients to be free – as far as the stage of their disease allows – to handle species of the garden, smell their scents and even taste their flavor, since there is no risk of intoxication. Similarly, "plants with textures that can hurt patients" should be avoided, in order to prevent injuries, scratches or deep wounds that can occur because of species with big thorns. In both clinics, vegetable species with forms that can cause light damages in residents can be found.

The Brazilian norm which regulates accessibility, NBR9050, recommends the "presence of support handrails" in order to assure safety walks for individuals with limited motor functions, such as patients with Alzheimer. Both clinics have handrails on their facilities, however, they are not present outdoors, in the grass areas. This shortcoming prevents patients from walking around freely in such areas and also limits their possibilities of having tactile stimuli produced by walking barefoot feeling the ground [16].

The presence of a "straight connection between indoor environments and the garden" favors the patients' locomotion and autonomy. It also establishes an access routine and a straight path, which helps patients to reach the garden without getting lost. A simple access for a healthy brain may be very complex for a brain with Alzheimer's disease. The hippocampus, the place where mental maps are formed, is affected by the disease, which impacts negatively in the individual's reasoning ability [3]. Considering this topic, both clinics fully accomplish the recommendations, providing direct and simple accesses to the garden.

"Garden maintenance" is fundamental for this area to remain clean, well maintained and free of risks or danger for patients. Indeed, both clinics care for their green areas keeping them clean, considering that dry leaves, twigs, and thorns can hurt and patients might take them in the mouth (Table 7).

Table 7. Scope of recommendation in the category "Safety and Conservation". Source: Authors.

Project Recommendation	SeniorVit Clinic	Recanto Monsenhor Albino
Presence of emergency doors	**[Fully accomplished].** There is an emergency gate on the back of the garden. The access to it is visible and safe.	**[Not accomplished].** No emergency exits or signs of it were identified.
Visibility of the entire garden perimeter	**[Fully accomplished].** There's a wide view of the garden.	**[Partially accomplished].** The landscape is quite wide and patients can find it difficult to grasp the entirety of the garden.
Existence of toxic plants	**[Fully accomplished].** No toxic plants present.	**[Fully accomplished].** No toxic plants present.
Existence of plant with textures that can hurt patients	**[Partially accomplished].** There are some species such as the phoenix palm tree that can hurt the face or hands of the patients.	**[Partially accomplished].** There are some species such as the phoenix palm tree and agaves that can hurt the face or hands of the patients.
Support handrails for walks on the green area	**[Partially accomplished].** The entire access to the garden has handrails, however, there is no support for walks on the green area.	**[Partially accomplished].** There are handrails on the path that leads to the green area, however, there is no support for walks on the grass area.
Straight connection between indoor environments and the garden	**[Fully accomplished].** The main living room is connected to the garden.	**[Fully accomplished].** The openings of the wings and shelters are connected to the green area.
Garden maintenance	**[Fully accomplished].** Maintenance is daily kept by a gardener. Patients are encouraged to help him under the supervision of the care staff.	**[Fully accomplished].** Maintenance is kept daily by a staff of gardeners

(h) Uses

The element "Uses" comprises six project recommendations. Regarding this last parameter, SeniorVit fully accomplishes four recommendations but does not comply with two. Recanto Monsenhor Albino fully accomplishes two, leaving two partially implemented and another two not implemented at all. The results are described below:

None of the clinics has "separate gardens" for different stages of Alzheimer. As the disease advances, the patient's brain is affected by changes in its structure, which cause the loss of certain cognitive and motor skills. Such losses, related to the different stages of this disease, require different approaches. Therefore, such recommendation aims to provide the patients with the best way for them to appropriate the space. In the first stage of the disease, pathways can still be more complex and topography can have more pronounced slopes. However, in the second stage, it is necessary to stimulate the patients' senses through scents, sounds, and a diverse landscape. Thus, the space should not have any type of obstacle or interference [13].

Regardless of the disease level, patients should be "encouraged to keep a relation of care with the garden", in order to create a routine and familiarity with the place [17]. This process, besides serving as a form of occupational therapy for patients, also evoke

affective memories of those who usually performed such activities before the manifestation of the disease, such as: garden care, watering plants, harvesting fruits and cultivating vegetable gardens. SeniorVit has a vegetable garden and a drinking fountain for birds, and patients are encouraged to take care of these equipments along with the clinic's staff. Recanto Monsenhor Albino also has a vegetable garden, and patients with less cognitive impairments are encouraged to plant and harvest.

Both "the care staff and residents' families use the green area" of both clinics. These spaces are used as socialization and celebration areas, reinforcing the encounter of individual and nature [10].

The "nocturnal use of the garden" is only available for SeniorVit patients. The huge green area of Recanto Monsenhor Albino is not appropriate for a safe walk or visitation on evenings, since the patient can get lost, become afraid or irritated due to the absence of light [13].

The "flexibility of use" is also a crucial parameter for a therapeutic garden. SeniorVit uses the green area for therapies, walks and celebrations during the day, and sometimes during the evening. Recanto Monsenhor Albino, in contrast, conducts therapy and physiotherapy sessions indoors, despite having a huge garden suited for these activities (Table 8).

Table 8. Scope of recommendations in the category "Uses"; Source: Authors.

Project Recommendation	SeniorVit Clinic	Recanto Monsenhor Albino
Separate gardens for the different stages of the disease	**[Not accomplished].** The garden is used by all the patients with no separation among disease stages.	**[Not accomplished].** Every patient enjoys the same area of the Garden with no separation among disease stages.
Elements encouraging patients to help in the care of the garden	**[Fully accomplished].** The vegetable garden and the drinking fountain for birds encourage patients to take part in the care routine of the garden.	**[Partially accomplished].** Besides taking care of the vegetable garden, patients are not encouraged to care for other spaces of the green area.
Uses of the garden by the care staff	**[Fully accomplished].** Care staff members use the garden to relax.	**[Fully accomplished].** All the care staff declares to use the garden for resting, contemplation and socializing.
Uses of the garden by families of the patients	**[Fully accomplished].** Families use the garden when visiting.	**[Fully accomplished].** Families use the garden when visiting.
Nocturnal use of the garden	**[Not accomplished].** Once a week patients – assisted by the care staff – take a walk on the garden for short periods of the evening, usually after dinner.	**[Not accomplished].** The garden is not used during the evening.
Garden configuration for the practice of therapies, socialization and diverse activities with every patient	**[Fully accomplished].** The annex building and the barbecue area work as extensions of the garden, where socialization and manual activities take place.	**[Partially accomplished].** Even though the area is suited for these activities, they are performed indoors.

4 Conclusion

Departing from studies about the brain and from an approach based on the cooperation between Architecture and Neuroscience, [1–6, 9] this research analyses and defends the strong potential of landscape projects for the promotion of wellness and life-quality of individuals with Alzheimer, considering such initiative as part of the set of non-pharmacological treatments for this disease. Both the analysis and the defense are structured: (1) on the concept of neuroplasticity, that indicates a clear co-evolution between the structure of the brain and the space someone inhabits. That is to say, the significant potential of the living environment of an individual to shape and mold the physical structure of the brain and, consequently, its behavior; as well as the expressive transformation of the physical space planned and executed by the human brain, activities encompassed by the fields of Architecture and Design; (2) on the concept of *biophilia*, that affirms the intrinsic and positive attachment between human being and nature. In other words, humans and nature are biologically connected, a lifelong deal with clear benefits for humankind; (3) on the concept of affective memory, which evinces how memories are modulated by emotions; and the contributions to the organism and wellness of humans, which derive from the stimuli (somatosensory, sensory-motor and cognitive) to evoke memories with positive emotional value.

The results obtained by the research indicate 45 project recommendations to the landscape project of clinics dedicated to the care of Alzheimer's disease patients. From these recommendations, 25 are derived from literature review [3, 11–16] and 20 come from field investigations undertaken on two clinics in the state of Sao Paulo, Brazil: SeniorVit (Campinas) and Recanto Monsenhor Albino (Catanduva).

At SeniorVit, 28 recommendations are fully accomplished, 9 partially accomplished and 8 not accomplished; at Recanto Monsenhor Albino, on the other hand, 23 recommendations are fully applied, 15 only partially, and 7 are not applied.

From the results obtained, it is possible to affirm that the absence of a landscape project specifically oriented towards the treatment of patients with Alzheimer and its use also by the care staff explains the deficiencies and the need of project improvements in both clinics. Such finding reaffirms the importance of landscaping in this type of space. Another point is that a directly proportional relation can be inferred between somatosensory, sensory-motor and cognitive benefits for the patients and the increase in the number of fully accomplished project recommendations.

It is important to stress the research gap in Brazilian literature concerning the contribution of landscaping projects to the non-pharmacological treatment of patients with Alzheimer. Therefore, the field investigations undertaken in this research are an important contribution. These investigations made it possible to increase the number of project recommendations for therapeutic gardens already available on international literature, while also adding new parameters of analysis stemming from the needs identified in the field. It is expected then that the set of parameters presented here can be used in further studies, and that it can also be expanded through new propositions generated by investigations performed either in Brazil or abroad. Such expansion strengthens the cooperation between Architecture, Design, and Neuroscience and promotes the wellness and life quality of patients with degenerative neurological diseases.

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