Review



# Sensory Integration: A Novel Approach for Healthy Ageing and Dementia Management

Ongart Maneemai , Maira Cristina Cujilan Alvarado , Lina Graciela Calderon Intriago , Alicia Jeanette Donoso Triviño , Joicy Anabel Franco Coffré , Domenico Pratico , Kristof Schwartz , Tadele Tesfaye , Takao Yamasaki *

Posted Date: 1 February 2024

doi: 10.20944/preprints202402.0066.v1

Keywords: Sensory Integration; Dementia; Neuromodulation; Healthy aging

 doi:10.20944/preprints202402.0066.v1



*Review*

# Sensory Integration: A Novel Approach for Healthy Ageing and Dementia Management

**Ongart Maneemai [1], Maira Cristina Cujilan Alvarado [2], Lina Graciela Calderon Intriago [2], Alicia Jeanette Donoso Triviño [2], Joicy Anabel Franco Coffré [2], Domenico Pratico [3], Kristof Schwartz [4,5], Tadele Tesfaye [6] and Takao Yamasaki [7,8,*]**

[1] Department of Pharmaceutical Care, School of Pharmaceutical Sciences, University of Phayao, Phayao, 56000, Thailand
[2] University of Guayaquil, School of Nursing, Guayaquil 090510, Ecuador
[3] Alzheimer's Center at Temple, Lewis Katz School of Medicine, Temple University, Philadelphia 19122, PA, USA
[4] Doctoral School of Psychology, ELTE Eötvös Loránd University, Budapest 1053, Hungary
[5] Institute of Health Promotion and Sport Sciences, ELTE Eötvös Loránd University, Budapest 1053, Hungary
[6] CareHealth Medical Practice, Jimma Road, Addis Ababa 9023, Ethiopia
[7] Department of Neurology, Minkodo Minohara Hospital, Fukuoka 811-2402, Japan
[8] Kumagai Institute of Health Policy, Fukuoka 816-0812, Japan
* Correspondence: yamasaki_dr@apost.plala.or.jp; Tel.: +81-92-947-0040

**Abstract:** Sensory processing is a crucial function of the nervous system that significantly affects a large portion of the population, particularly older individuals who may be dealing with different forms of dementia. The global population of people aged 65 or older has reached a substantial count of around 703 million, representing approximately 9% of the total global population. Within this demographic, an estimated 5-8% of those aged 60, highlighting the growing need to address sensory modulation challenges for healthy aging. Sensory diet, derived from sensory integration theory, provide a tailored approach to modulating sensory experiences and triggering neuroplastic changes in the brain. Recent neuroimaging studies have revealed intricate structural and functional alterations in the brain associated with the implementation of sensory diets. Furthermore, the integration of the Metaverse, augmented reality, and virtual reality has opened up personalized experiences, fostering cognitive stimulation and emotional well-being for individuals during aging. This article offers a comprehensive exploration of the effectiveness of sensory diets in enhancing attentional control, self-regulation, and alleviating sensory-related distress among the healthy aging and dementia population. By employing precise quantitative evaluations such as sensory processing scales and advanced neuroimaging methodologies, it presents solid evidence of the tangible impact of these interventions. Emphasizing the importance of interdisciplinary cooperation and leveraging technological advancements, the article underscores the crucial need for customized sensory diets to optimize sensory processing and improve the overall well-being of older individuals contending with sensory modulation challenges and dementia.

**Keywords:** Sensory Integration; Dementia; Neuromodulation; Healthy aging

## 1. Introduction

The notion of a "sensory diet" represents a novel and emerging paradigm aimed at optimizing sensory processing mechanisms in individuals, with implications for various neurobehavioral contexts. Rooted in the foundational principles of sensory integration theory, sensory diets are intricately designed interventions predicated on the precise manipulation of sensory stimuli and activities to ameliorate sensory processing anomalies [1,2].

 doi:10.20944/preprints202402.0066.v1



Central to this concept is the recognition that the human nervous system is intrinsically responsible for receiving, interpreting, and responding to sensory input from the surrounding environment. Dysfunctions or irregularities in this process can manifest as sensory sensitivities, hyposensitivity, or sensory-seeking behaviors, thereby impinging upon an individual's capacity to function optimally in daily life [3]. Sensory diets, firmly grounded in the theoretical framework developed by A. Jean Ayres, have garnered scientific attention for their potential to redress these issues [4].

These diets encompass a diverse repertoire of sensory modalities, including tactile, proprioceptive, vestibular, auditory, and visual stimuli, which are methodically integrated into personalized regimens [5].

In recent time, advancements in the field of sensory diets have been significant, driven by ongoing research and an increasing understanding of sensory processing. These advancements aim to optimize the effectiveness of sensory interventions for individuals with sensory modulation difficulties. Several key areas where advancements have occurred include:

1. Personalization and Precision: A notable advancement in sensory diet is the increased emphasis on personalized sensory diets. Rather than adopting a one-size-fits-all approach, experts now recognize the importance of tailoring sensory interventions to an individual's unique sensory profile. This involves comprehensive assessments and the integration of an individual's sensory preferences and sensitivities into the intervention plan [6].

2. Technology Integration: Technology has played a crucial role in advancing sensory diets. Virtual reality (VR), sensory apps, augmented reality (AR) like technologies are being integrated into sensory interventions which offer immersive sensory experiences in controlled environments. These technologies allow therapists to create highly customized sensory input and monitor patient progress more effectively [7].

3. Tele-health and Remote Interventions: The–need arising from the COVID-19 pandemic catalyzed the rapid integration of tele-health systems, has revolutionized the landscape of sensory therapy interventions within the healthcare domain. Since conventional face-to-face therapy sessions faced constraints during the pandemic hours, the incorporation of virtual sensory therapy sessions emerged as a pivotal response, which employed advanced digital communication technologies to bridge the gap between therapists and patients [8–10]. This paradigm shift not only addressed the immediate necessity for remote care but also unearthed novel avenues for research and development in the domain of tele-health-driven sensory interventions. Leveraging cutting-edge telecommunication infrastructure and sophisticated digital tools, therapists were able to effectively conduct real-time sensory assessments, interventions, and continuous monitoring, facilitating tailored treatment plans for patients. This assimilation of telehealth services extended the outreach of sensory therapy in establishing robust frameworks for data security, privacy, and regulatory compliance ensuring the confidentiality of patient information and upholding ethical standards within the digital healthcare milieu [11,12].

4. Integration of Mindfulness and Behavioral Strategies: Sensory diets are increasingly incorporating mindfulness techniques and behavioral strategies to help individuals develop self-awareness and self-regulation skills. These strategies can complement sensory interventions, promoting long-term positive outcomes [13].

As a result, the trajectory of sensory diets represents a promising avenue for addressing complex sensory processing challenges. With an emphasis on personalized methodologies, technological integration, and collaborative interdisciplinary efforts, it offers multifaceted solutions. Continued research and the integration of advanced technologies are poised to further optimize the efficacy and accessibility of sensory interventions, benefiting individuals navigating sensory processing difficulties.

## 2. Understanding Sensory Needs in Aging

The process of aging is characterized by a complex interplay of physiological changes, prominently including alterations in sensory perception. In the context of healthy aging, the

 doi:10.20944/preprints202402.0066.v1



multifaceted decline in sensory modalities represents a natural progression that individuals undergo as they age. Visual perception, in particular, undergoes changes that collectively contribute to a nuanced shift in the way individuals interact with and perceive their surroundings. This can make tasks like reading, recognizing small objects, or discerning intricate visual information more challenging, further exacerbating the impact on daily activities. The decline in visual acuity, coupled with compromised optic flow motion perception, as seen in aging and conditions like Alzheimer's disease, intensifies the complexities of spatial orientation and navigation [14,15]. Patients not only struggle with fine visual tasks but also experience difficulties in interpreting the motion of objects and accurately gauging distances in their environment. Consequently, these interconnected changes highlight the importance of tailored interventions, encompassing environmental modifications and technological solutions, to address the multifaceted nature of age-related and neurodegenerative alterations in visual perception [16–18].

Compromised depth perception, another facet of healthy aging, involves difficulties in accurately perceiving distances and spatial relationships [19]. This aspect becomes particularly relevant in activities where judging depth is crucial, such as navigating stairs, reaching for objects, or participating in sports. The aging process also brings about heightened sensitivity to glare, making bright lights and sunlight more uncomfortable and potentially disruptive to daily activities [20].

These sensory changes collectively present substantial challenges in performing fundamental tasks essential for daily living. Reading may require increased effort or the use of visual aids, driving can become more challenging due to altered depth perception and sensitivity to glare, and navigating unfamiliar environments may pose additional obstacles [21] as illustrated in Figure 1.

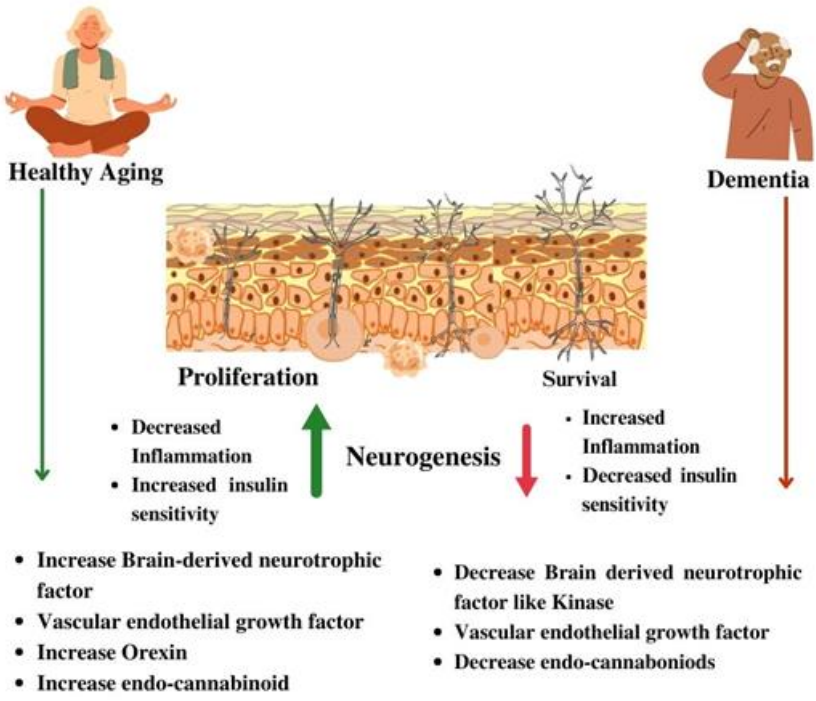


**Figure 1.** Schematic representation reflecting neuroplasticity changes.

At the same time, in dementia conditions like Alzheimer's disease, which causes a decline in thinking abilities, the brain faces challenges in adapting and forming new connections, a process known as neuroplasticity. Alzheimer's brings problems like insoluble deposits of substances (beta-amyloid plaques and tau tangles) that disrupt communication between brain cells. While the brain tries to compensate for cell loss, it can struggle to make enough changes, especially as the disease gets worse. Factors like education and staying mentally active, known as cognitive reserve, play a big role in how symptoms show up. Also, changes in brain chemicals, like not having enough acetylcholine, can contribute to the decline in thinking.

 doi:10.20944/preprints202402.0066.v1



The interconnected nature of these sensory changes underscores the complexity of challenges faced by the aging population. Comprehensive scientific approaches are imperative for understanding and addressing these multifaceted issues, offering avenues to enhance the quality of life for elderly individuals. Research in neuroplasticity, the molecular mechanisms underlying, and sensory system alterations has contributed to the development of targeted sensory diet interventions which aim at mitigating the impact of age-related sensory decline and cognitive impairment [22].

*2.1. The Role of Sensory Diet in Dementia Management*

In the landscape of dementia management, the role of sensory diets stands as a compelling avenue, providing a tailored and integrative approach to alleviate symptoms and enhance the well-being of individuals affected by this complex neurological condition. While pharmacological interventions remain a cornerstone of treatment, the growing recognition of non-pharmacological approaches, such as sensory diets, is transforming the landscape of dementia care [23] represented in Figure 2.

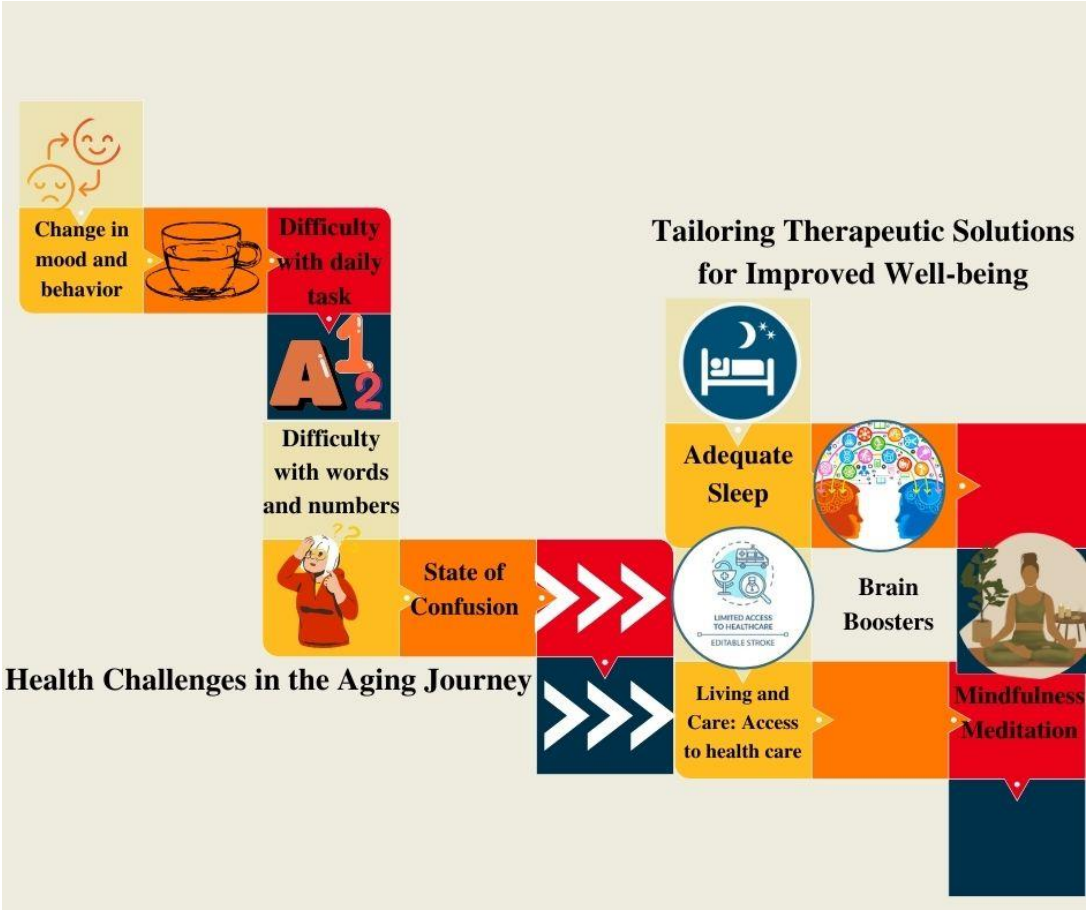


**Figure 2.** Schematic representation reflecting health challenge during aging with tailored therapeutic solutions.

Neuroplasticity, the capacity of the brain to reorganize itself through synaptic and structural modifications, plays a pivotal role in shaping cognitive trajectories across the human lifespan. In the developmental phase, particularly during early life, neuroplasticity is prominently evident, facilitating the acquisition of cognitive skills, memory formation, and the establishment of neural circuits critical for learning. As individuals progress through the aging continuum, the brain undergoes intricate changes in both structure and function. Despite the inevitability of some decline, neuroplasticity remains a crucial mechanism for the adaptive recalibration of neural networks.

In healthy aging, neuroplasticity plays a crucial role in mitigating cognitive decline. Individuals who are actively engaged in intellectually stimulating activities, maintain robust social connections,

 doi:10.20944/preprints202402.0066.v1



and pursue continuous learning endeavors exhibit a capacity to induce favorable neuroplastic changes. This phenomenon contributes to the concept of cognitive reserve, wherein the brain's resilience to age-related alterations is fortified, leading to sustained cognitive abilities despite structural transformations.

Conversely, the narrative shifts markedly in the landscape of dementia-related aging. Here, neuroplasticity encounters formidable challenges. The accumulation of aberrant protein aggregates, disrupts synaptic transmission and undermines the adaptive potential of neuroplasticity. Consequently, the brain's ability to form new connections and adapt to changing circumstances is severely compromised, contributing significantly to the cognitive deterioration observed in dementia.

Comprehending the nuanced interplay of neuroplasticity in these diverse contexts is imperative for devising strategies to optimize cognitive health. In the realm of healthy aging, interventions aimed at promoting neuroplasticity enriching activities, such as cognitive training and physical exercise, emerge as potential pathways to support cognitive well-being.

Fostering an understanding of the intricate interplay between sensory inputs and cognitive responses, the implementation of individualized sensory diets has gained traction for its potential. Tailoring interventions to meet specific sensory needs, healthcare professionals have demonstrated a profound commitment to enhancing the overall well-being and quality of life for individuals grappling with the complexities of this neurodegenerative condition [24].

The incorporation of sensory diets into dementia management offers a range of benefit primarily centered around their ability to mitigate the emotional distress and behavioral symptoms often associated with the condition [25]. Such interventions have been found to contribute to improve the sense of well-being, enhancing the overall quality of life of patient. For instance, in a recent study Wójick et al., aimed to assess the current usage and acceptance of technology, specifically smartphones and computers, among 102 dementia caregivers, with a focus on socio-demographic factors. The findings of the study indicated that a significant majority of caregivers, particularly women, used smartphones and computers. The study further revealed that age, gender, and education level influenced the acceptance of technology, with smartphone use being more widespread across all age groups, whereas computer use was more common among younger caregivers. The respondents perceived technology as highly beneficial for facilitating various activities such as locomotion, toileting, and meal management for the patients [26]. Likewise Hwang et al., analyzed 2051 participants, highlighting the considerable impact of dual sensory impairment (DSI) on the risk of all-cause dementia and Alzheimer's disease. Notably, while visual impairment independently for all-cause dementia, the combined effect of both sensory impairments posed a more substantial risk. These findings underscore the significance of addressing sensory impairments, particularly DSI, as a potential risk factor in dementia, suggesting potential avenues for preventive interventions and further research [27].

Furthermore, sensory diets have demonstrated effectiveness in regulating sleep patterns, which are commonly disrupted in individuals with dementia as illustrated in Figure 3. Sleep disturbances not only exacerbate cognitive decline but also contribute to increased agitation and confusion. Evidence derived from recent studies highlights the efficacy of integrating sensory activities aimed at inducing relaxation and creating a conducive sleep environment for individuals with dementia [28]. These interventions have been associated with notable improvements in overall mood and cognitive functioning. Such positive outcomes emphasize the critical role of sensory-based interventions in optimizing the care and management of individuals living with dementia, pointing towards a promising avenue for enhancing their quality of life [29].

 doi:10.20944/preprints202402.0066.v1



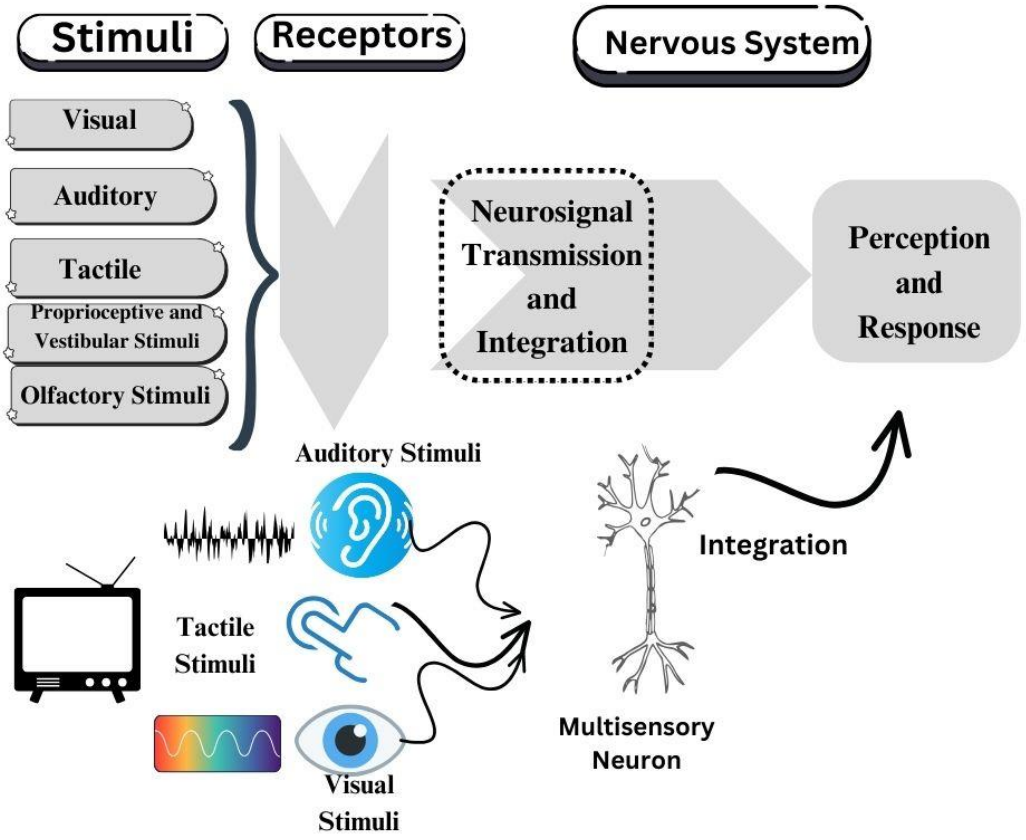


**Figure 3.** Schematic representation of multi-sensory stimulation.

In addition to their impact on emotional well-being, sensory diets play a crucial role in preserving cognitive abilities and stimulating neural plasticity in individuals with dementia. By incorporating activities that engage various senses, such as reminiscence therapy, multisensory experiences, and cognitive games, these diets help maintain cognitive functions, including memory, attention, and executive function [30] as represented in Figure 4. Regular engagement in cognitive-stimulating sensory activities not only aids in the preservation of cognitive abilities but also promotes social interaction, reducing the feelings of isolation and loneliness that often accompany the progression of the disease.

 doi:10.20944/preprints202402.0066.v1



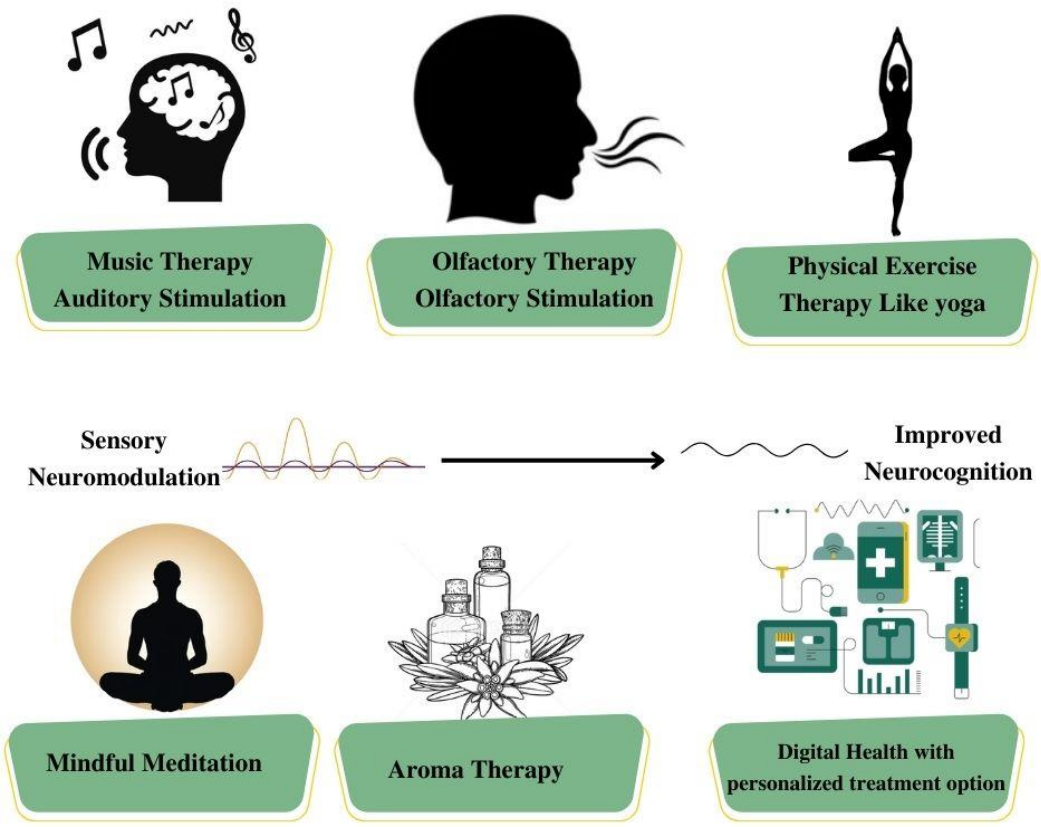


**Figure 4.** Schematic representation of different sensory activities for healthy patients and well-being of dementia patients.

Sensory diets also contribute significantly to the overall physical well-being of individuals in both healthy and dementia aging. By integrating sensory activities that involve movement, balance, and coordination, caregivers can help maintain muscle strength, joint flexibility, and overall physical health. Engaging in activities such as light exercise, dance therapy, or sensory-based physical activities not only promotes physical health but also enhances the overall sense of well-being and self-confidence in individuals in both cases. Additionally, these activities help reduce the risk of falls and injuries, which can be particularly detrimental to individuals with impaired cognitive function [31,32].

The positive impacts of sensory diets on cognitive function are closely linked to the fundamental brain mechanisms that regulate sensory processing, integration, and neuroplasticity. These diets, involving systematic exposure to diverse sensory experiences, stimulate neuroplasticity by influencing synaptic plasticity, thereby optimizing the efficiency of neuronal connections critical for learning and memory [33]. Leveraging the brain's intricate sensory integration mechanisms, sensory diets promote the integration of diverse sensory inputs, enhancing the brain's ability to create a cohesive perception of the environment and facilitating improved cognitive processing. The activation of specific brain regions in response to varied stimuli ensures holistic cognitive stimulation, while the release of neurotransmitters such as dopamine and serotonin contributes to mood regulation and attention [34]. Furthermore, sensory diets, tailored to individual preferences, fine-tune the reticular activating system, promoting sustained attention and focus. Importantly, these interventions also influence stress response systems, reducing cortisol levels and creating a conductive environment for optimal cognitive functioning. Thus, the positive impact of sensory diets on cognitive function arises from their ability to modulate neuroplasticity, promote sensory integration, activate specific brain regions, regulate neurotransmitter release, enhance attention, and alleviate stress [35]. Understanding these underlying brain mechanisms is crucial for designing

 doi:10.20944/preprints202402.0066.v1



effective sensory interventions that cater to individual needs and contribute to overall cognitive well-being.

## 3. Implementing a Customized Sensory Diet: Strategies for Effective Application

Implementing customized sensory diet has gained traction as a non-pharmacological intervention that can significantly improve the quality of life for individuals. A sensory diet tailored to the specific needs and preferences of each individual can provide a structured and engaging routine that fosters emotional well-being, cognitive stimulation, and physical health. Different strategies for effectively implementing a customized sensory diet involve [36]:

1. Comprehensive Assessment: A successful sensory diet implementation begins with a comprehensive assessment of the individual's sensory preferences, cognitive abilities, and current emotional and physical well-being. Understanding the specific sensory sensitivities and aversions of the person with dementia is crucial for tailoring the sensory diet to their unique requirements.

2. Individualized Plan Development: Based on the assessment, create a personalized sensory diet plan that includes a variety of sensory activities targeting different senses. Incorporate activities that the individual enjoys and that promote relaxation, cognitive engagement, and physical activity. The plan should be flexible and adaptable to accommodate changes in the individual's condition over time. For instance Rivan et al., conducted a study among Malaysian community-dwelling older adults aimed to explore the impact of dietary patterns on mild cognitive impairment and dementia incidence. The 5-year follow-up analysis of 280 participants aged 60 years and above encompassed various assessments, including cognitive, psychosocial, and functional evaluations, along with dietary intake data. The result of the study indicated that "local snacks-fish and seafood-high salt foods" pattern increased the risk of mild cognitive impairment, while the "tropical fruits-oats" pattern showed a protective effect against dementia. These findings underscore the importance of dietary choices in influencing cognitive outcomes in the aging population [5].

3. Multi-Sensory Stimulation: Integrating activities that engage multiple senses simultaneously to maximize the benefits of sensory stimulation. This may include incorporating music therapy, aromatherapy, tactile experiences, and visual stimuli in a coordinated manner to create a rich and immersive sensory environment that promotes emotional comfort and cognitive engagement [37] as represented in Figure 4.

For instance, Sánchez et al., in their study aimed to compare the effects of a multisensory stimulation environment (MSSE) and one-to-one activity sessions on elderly individuals with severe dementia. Thirty-two participants were divided into groups and engaged in regular sessions over 16 weeks. The results revealed that the MSSE group exhibited significant improvements in neuropsychiatric symptoms and dementia severity compared to the one-to-one activity group. Both groups showed improved agitation scores during the intervention, with no significant differences between them. The study suggests that MSSE could be more effective in managing symptoms of severe dementia than one-to-one activity sessions [38].

4. Regular Evaluation and Adjustment: Regularly evaluate the effectiveness of the sensory diet in meeting the individual's emotional, cognitive, and physical needs. Adjust the plan as necessary to accommodate changes in the individual's preferences, abilities, and overall condition. Continual monitoring and adaptation are essential to ensure that the sensory diet remains relevant and beneficial [8].

## 4. Innovative Convergence: Exploring the Intersection of Sensory Diets and Technology for Enhanced Support in Sensory Processing Difficulties

In recent years, the convergence of sensory diets and technology has ushered in innovative solutions to support individuals in managing their sensory needs. The amalgamation of different fields resulted in-a range of applications and devices aiming to provide tailored sensory experiences to aid individuals in their daily lives [39] as represented in Figure 5.

 doi:10.20944/preprints202402.0066.v1



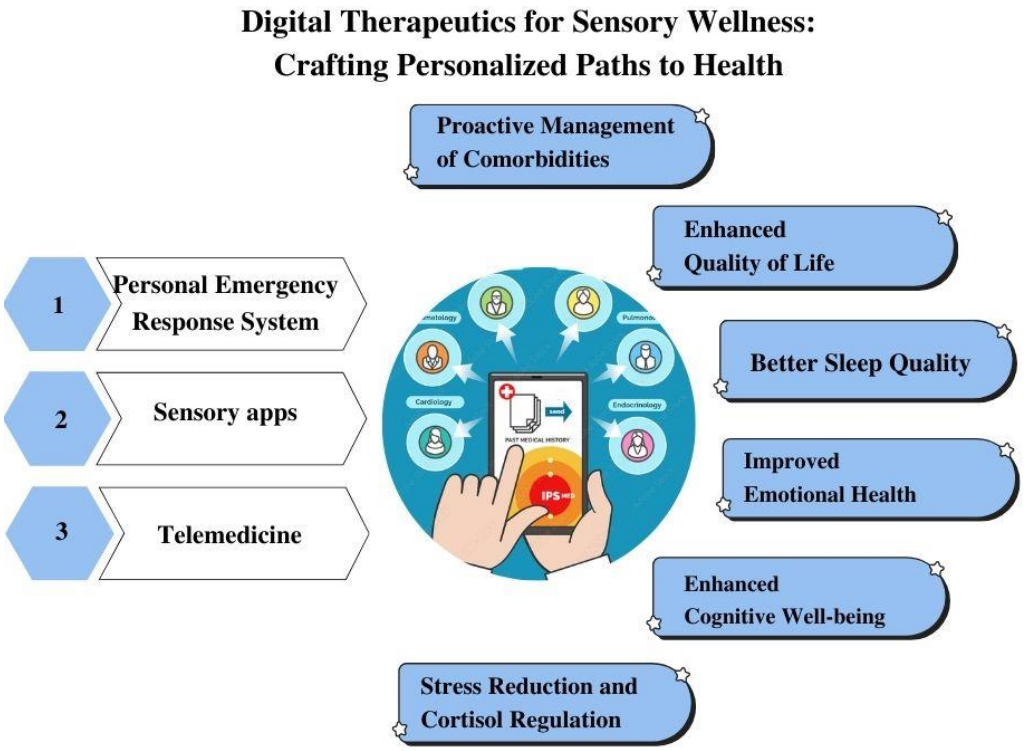


**Figure 5.** Schematic representation of technological solution for different aging communities.

One of the most notable developments is the proliferation of sensory apps. These apps cater to individuals with sensory processing difficulties, offering a plethora of activities specifically designed to provide sensory input. From soothing sounds that promote relaxation to visually stimulating graphics that encourage focus and engagement, these apps serve as valuable tools for individuals seeking to regulate their sensory experiences. Moreover, the interactive nature of these apps fosters engagement and active participation, thereby facilitating improved sensory regulation over time [40]. Another study by Kuo et al., examined mobile applications for dementia care across different languages and during the COVID-19 pandemic, recognizing the global impact of dementia individuals and their communities. The analysis, conducted using the Mobile Application Rating Scale (MARS), revealed no significant disparity in MARS scores between English and Chinese language apps. Additionally, while the apps developed during the COVID-19 pandemic demonstrated marginally higher MARS scores compared to those before the pandemic, this difference was not statistically. Despite these findings, the study emphasized the necessity for collaborative efforts among dementia professionals, technology experts, and caregivers to provide user-friendly, evidence-based information, underlining the importance of tailored resources to address the diverse needs of users [41].

Beyond digital interfaces, the integration of technology into wearable sensory devices has garnered significant attention. Sensory-friendly clothing and accessories equipped with specialized mechanisms have emerged as practical solutions to provide deep pressure input and sensory stimulation. These wearable are designed to offer individuals a continuous source of sensory input throughout the day, thereby aiding in their sensory regulation. By seamlessly incorporating technology into these wearable, individuals can benefit from discreet and convenient sensory support without compromising their comfort or mobility [42].

Furthermore, the advent of VR and AR has unlocked a realm of possibilities for creating controlled sensory environments. Through VR and AR technologies, individuals can immerse themselves in simulated settings that offer customizable sensory experiences. These controlled

 doi:10.20944/preprints202402.0066.v1



environments can be tailored to accommodate specific sensory preferences, thereby allowing individuals to engage with sensory input in a safe and controlled manner. By leveraging VR and AR, individuals can access a diverse array of sensory stimuli that can be adjusted to meet their unique sensory requirements [43,44].

The utilization of metaverse technologies in aiding individuals with cognitive impairments, such as dementia, presents a promising avenue for enhancing cognitive abilities and overall well-being. By developing immersive virtual environments that simulate familiar real-life settings and activities, individuals with dementia can engage in therapeutic experiences that facilitate memory consolidation, cognitive stimulation, and emotional regulation. VR simulations can effectively recreate past experiences, thereby facilitating the application of reminiscence therapy, while also providing interactive cognitive exercises tailored to individual cognitive profiles. Moreover, the metaverse can serve as a conductive platform for fostering social interaction and reducing feelings of social isolation commonly experienced by individuals living with cognitive impairments. Nonetheless, the ethical implications, privacy concerns, and accessibility issues must be carefully considered and addressed to ensure responsible and effective integration of these technologies in supporting individuals with cognitive limitations [45,46].

Tech companies have also responded to the demand for sensory-friendly devices by introducing specialized product lines that cater to individuals with sensory sensitivities. These devices are equipped with features such as reduced screen brightness, color filters, or noise-cancelling options, thereby providing a conductive sensory environment for its users. By incorporating these sensory-friendly features, technology companies are fostering inclusivity and accessibility, ensuring that individuals with sensory challenges can seamlessly integrate technology into their daily lives.

As the intersection of sensory diets and technology continues to evolve, the ongoing innovation and integration of these solutions hold significant promise in enhancing the quality of life for individuals with sensory processing difficulties.

## 5. Conclusions

The sensory diet paradigm represents a scientifically grounded and pragmatic approach for optimizing healthy aging and mitigating the challenges associated with dementia. Anchored in the profound influence of multisensory experiences on neurocognitive and emotional parameters, the sensory diet framework provides a nuanced, individualized strategy to elevate the overall quality of life in aging populations and those grappling with dementia. Through the systematic integration of diverse sensory stimuli encompassing tactile, auditory, visual, and olfactory modalities this approach transcends conventional care models. It facilitates cognitive engagement, emotional homeostasis, and a conducive environment for both individuals and caregivers. In navigating the intricate facets of the aging process, the adoption of sensory diet principles not only signifies an innovative scientific pursuit but also underscores a compassionate and empirically validated avenue to cultivate resilience, uphold dignity, and instill a profound sense of purpose throughout the continuum of aging.

**Author Contributions:** Conceptualization, O.M., J.A.F.C. and T.T.; methodology, O.M., J.A.F.C. and T.T.; investigation, M.C.C.A. and L.G.C.I.; writing—original draft preparation, O.M., M.C.C.A., L.G.C.I., A.J.D.T., D.P. and K.S.; writing—review and editing, J.A.F.C., D.P., T.T. and T.Y.; visualization, M.C.C.A. and A.J.D.T.; supervision, T.T. and T.Y. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** Not applicable.

**Conflicts of Interest:** The authors declare no conflicts of interest.

 doi:10.20944/preprints202402.0066.v1



## References


1. Mileski M, Baar Topinka J, Brooks M, Lonidier C, Linker K, Vander Veen K. Sensory and memory stimulation as a means to care for individuals with dementia in long-term care facilities. Clin Interv Aging. 2018 May 17;13:967–74.
2. Malek Rivan NF, Shahar S, Fakhruddin NNINM, You YX, Che Din N, Rajikan R. The effect of dietary patterns on mild cognitive impairment and dementia incidence among community-dwelling older adults. Frontiers in Nutrition [Internet]. 2022 [cited 2023 Oct 18];9. Available from: https://www.frontiersin.org/articles/10.3389/fnut.2022.901750
3. Costa-López B, Ferrer-Cascales R, Ruiz-Robledillo N, Albaladejo-Blázquez N, Baryła-Matejczuk M. Relationship between Sensory Processing and Quality of Life: A Systematic Review. J Clin Med. 2021 Aug 31;10(17):3961.
4. Kilroy E, Aziz-Zadeh L, Cermak S. Ayres Theories of Autism and Sensory Integration Revisited: What Contemporary Neuroscience Has to Say. Brain Sci. 2019 Mar 21;9(3):68.
5. Camarata S, Miller LJ, Wallace MT. Evaluating Sensory Integration/Sensory Processing Treatment: Issues and Analysis. Front Integr Neurosci. 2020 Nov 26;14:556660.
6. Svob Strac D, Konjevod M, Sagud M, Nikolac Perkovic M, Nedic Erjavec G, Vuic B, et al. Personalizing the Care and Treatment of Alzheimer's Disease: An Overview. Pharmacogenomics and Personalized Medicine. 2021 May 28;14:631–53.
7. Crofton EC, Botinestean C, Fenelon M, Gallagher E. Potential applications for virtual and augmented reality technologies in sensory science. Innovative Food Science & Emerging Technologies. 2019 Aug 1;56:102178.
8. Tian K, Sautter P, Fisher D, Fischbach S, Luna-Nevarez C, Boberg K, et al. Transforming Health Care: Empowering Therapeutic Communities through Technology-Enhanced Narratives. Journal of Consumer Research. 2014 Aug 1;41(2):237–60.
9. Shaikh TA, Dar TR, Sofi S. A data-centric artificial intelligent and extended reality technology in smart healthcare systems. Soc Netw Anal Min. 2022 Sep 1;12(1):122.
10. Vuillier L, May L, Greville-Harris M, Surman R, Moseley RL. The impact of the COVID-19 pandemic on individuals with eating disorders: the role of emotion regulation and exploration of online treatment experiences. J Eat Disord. 2021 Jan 12;9(1):10.
11. Valentino LA, Skinner MW, Pipe SW. The role of telemedicine in the delivery of health care in the COVID-19 pandemic. Haemophilia. 2020 Sep;26(5):e230–1.
12. Yi JS, Pittman CA, Price CL, Nieman CL, Oh ES. Telemedicine and Dementia Care: A Systematic Review of Barriers and Facilitators. Journal of the American Medical Directors Association. 2021 Jul 1;22(7):1396-1402.e18.
13. Vago D, David S. Self-awareness, self-regulation, and self-transcendence (S-ART): a framework for understanding the neurobiological mechanisms of mindfulness. Frontiers in Human Neuroscience [Internet]. 2012 [cited 2023 Oct 18];6. Available from: https://www.frontiersin.org/articles/10.3389/fnhum.2012.00296
14. Huang H, Wu J, Chang Y, Wang H, Tian Y, Chen Z, et al. Molecular and Cellular Mechanisms of Neuropathic Pain in Aging. ACS Chem Neurosci. 2023 May 17;14(10):1701–16.
15. Deery HA, Di Paolo R, Moran C, Egan GF, Jamadar SD. The older adult brain is less modular, more integrated, and less efficient at rest: A systematic review of large-scale resting-state functional brain networks in aging. Psychophysiology. 2023;60(1):e14159.
16. Yamasaki T, Tobimatsu S. Driving Ability in Alzheimer Disease Spectrum: Neural Basis, Assessment, and Potential Use of Optic Flow Event-Related Potentials. Front Neurol. 2018;9:750.
17. Yamasaki T, Horie S, Ohyagi Y, Tanaka E, Nakamura N, Goto Y, et al. A Potential VEP Biomarker for Mild Cognitive Impairment: Evidence from Selective Visual Deficit of Higher-Level Dorsal Pathway. J Alzheimers Dis. 2016 May 23;53(2):661–76.
18. Yamasaki T, Goto Y, Ohyagi Y, Monji A, Munetsuna S, Minohara M, et al. Selective impairment of optic flow perception in amnestic mild cognitive impairment: evidence from event-related potentials. J Alzheimers Dis. 2012;28(3):695–708.
19. Ramalho A, Petrica J. The Quiet Epidemic: An Overview of Emerging Qualitative Research Trends on Sedentary Behavior in Aging Populations. Healthcare. 2023 Jan;11(15):2215.
20. Fortunato S, Forli F, Guglielmi V, De Corso E, Paludetti G, Berrettini S, et al. A review of new insights on the association between hearing loss and cognitive decline in ageing. Acta Otorhinolaryngol Ital. 2016 Jun;36(3):155–66.
21. Cai Y, Song W, Li J, Jing Y, Liang C, Zhang L, et al. The landscape of aging. Sci China Life Sci. 2022 Dec 1;65(12):2354–454.
22. López-Otín C, Blasco MA, Partridge L, Serrano M, Kroemer G. Hallmarks of aging: An expanding universe. Cell. 2023 Jan 19;186(2):243–78.

23. Duboc H, Latrache S, Nebunu N, Coffin B. The Role of Diet in Functional Dyspepsia Management. Frontiers in Psychiatry [Internet]. 2020 [cited 2023 Oct 18];11. Available from: https://www.frontiersin.org/articles/10.3389/fpsyt.2020.00023
24. Blackwell SE. Mental Imagery in the Science and Practice of Cognitive Behaviour Therapy: Past, Present, and Future Perspectives. J Cogn Ther. 2021 Mar 1;14(1):160–81.
25. Rajiyah T. Sensory stimulation in the treatment of neuropsychiatric symptoms of dementia. 2023 Aug 1 [cited 2023 Oct 18]; Available from: https://repository.rcsi.com/articles/journal_contribution/Sensory_stimulation_in_the_treatment_of_neuropsychiatric_symptoms_of_dementia/23523951/1
26. Wójcik D, Szczechowiak K, Konopka P, Owczarek M, Kuzia A, Rydlewska-Liszkowska I, et al. Informal Dementia Caregivers: Current Technology Use and Acceptance of Technology in Care. International Journal of Environmental Research and Public Health. 2021 Jan;18(6):3167.
27. Hwang PH, Longstreth Jr W t., Brenowitz WD, Thielke SM, Lopez OL, Francis CE, et al. Dual sensory impairment in older adults and risk of dementia from the GEM Study. Alzheimer's & Dementia: Diagnosis, Assessment & Disease Monitoring. 2020;12(1):e12054.
28. van Hoof J, Kort HSM, Duijnstee MSH, Rutten PGS, Hensen JLM. The indoor environment and the integrated design of homes for older people with dementia. Building and Environment. 2010 May 1;45(5):1244–61.
29. Dominguez LJ, Veronese N, Vernuccio L, Catanese G, Inzerillo F, Salemi G, et al. Nutrition, Physical Activity, and Other Lifestyle Factors in the Prevention of Cognitive Decline and Dementia. Nutrients. 2021 Nov;13(11):4080.
30. Phillips C. Lifestyle Modulators of Neuroplasticity: How Physical Activity, Mental Engagement, and Diet Promote Cognitive Health during Aging. Neural Plasticity. 2017 Jun 12;2017:e3589271.
31. Woodbridge R, Sullivan M, Harding E, Crutch S, Gilhooly K, Gilhooly M, et al. Use of the physical environment to support everyday activities for people with dementia: A systematic review. Dementia. 2018 Jul 1;17(5):533–72.
32. Brett L, Traynor V, Stapley P. Effects of Physical Exercise on Health and Well-Being of Individuals Living With a Dementia in Nursing Homes: A Systematic Review. Journal of the American Medical Directors Association. 2016 Feb 1;17(2):104–16.
33. Gómez-Pinilla F. Brain foods: the effects of nutrients on brain function. Nat Rev Neurosci. 2008 Jul;9(7):568–78.
34. Zavitz E, Price NSC. Understanding Sensory Information Processing Through Simultaneous Multi-area Population Recordings. Frontiers in Neural Circuits [Internet]. 2019 [cited 2024 Jan 16];12. Available from: https://www.frontiersin.org/articles/10.3389/fncir.2018.00115
35. McCarty R. Learning about stress: neural, endocrine and behavioral adaptations. Stress. 2016 Jun 13;19:1–30.
36. Hazen EP, Stornelli JL, O'Rourke JA, Koesterer K, McDougle CJ. Sensory Symptoms in Autism Spectrum Disorders. Harvard Review of Psychiatry. 2014 Apr;22(2):112.
37. Sánchez A, Millán-Calenti JC, Lorenzo-López L, Maseda A. Multisensory Stimulation for People With Dementia: A Review of the Literature. Am J Alzheimers Dis Other Demen. 2013 Feb 1;28(1):7–14.
38. Sánchez A, Marante-Moar MP, Sarabia C, de Labra C, Lorenzo T, Maseda A, et al. Multisensory Stimulation as an Intervention Strategy for Elderly Patients With Severe Dementia: A Pilot Randomized Controlled Trial. Am J Alzheimers Dis Other Demen. 2016 Jun 1;31(4):341–50.
39. Dixon E, Lazar A. The Role of Sensory Changes in Everyday Technology use by People with Mild to Moderate Dementia. In: Proceedings of the 22nd International ACM SIGACCESS Conference on Computers and Accessibility [Internet]. New York, NY, USA: Association for Computing Machinery; 2020 [cited 2023 Oct 18]. p. 1–12. (ASSETS '20). Available from: https://doi.org/10.1145/3373625.3417000
40. Zgonec S. Mobile apps supporting people with dementia and their carers: Literature Review and Research Agenda. IFAC-PapersOnLine. 2021 Jan 1;54(13):663–8.
41. Kuo HL, Chang CH, Ma WF. A Survey of Mobile Apps for the Care Management of Patients with Dementia. Healthcare (Basel). 2022 Jun 23;10(7):1173.
42. García-Requejo A, Pérez-Rubio MC, Villadangos JM, Hernández Á. Activity Monitoring and Location Sensory System for People With Mild Cognitive Impairments. IEEE Sensors Journal. 2023 Mar;23(5):5448–58.
43. Baragash RS, Aldowah H, Ghazal S. Virtual and augmented reality applications to improve older adults' quality of life: A systematic mapping review and future directions. DIGITAL HEALTH. 2022 Jan 1;8:20552076221132100.
44. Tay JL, Xie H, Sim K. Effectiveness of Augmented and Virtual Reality-Based Interventions in Improving Knowledge, Attitudes, Empathy and Stigma Regarding People with Mental Illnesses—A Scoping Review. Journal of Personalized Medicine. 2023 Jan;13(1):112.

 doi:10.20944/preprints202402.0066.v1



45. Laukkanen T, Xi N, Hallikainen H, Ruusunen N, Hamari J. Virtual technologies in supporting sustainable consumption: From a single-sensory stimulus to a multi-sensory experience. International Journal of Information Management. 2022 Apr 1;63:102455.
46. Fuentes S, Tongson E, Gonzalez Viejo C. Novel digital technologies implemented in sensory science and consumer perception. Current Opinion in Food Science. 2021 Oct 1;41:99–106.