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Volume #2

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Semi-immersive Virtual Habitat to Enhance Relaxation in People with Dementia during COVID-19 Emergency

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Abstract | The effects of lockdown-induced isolation, with changes in daily routines and reduction of emotional, social and physical stimuli, have been a detonator for the rapid increase of neuropsychiatric disorders among fragile elderly, such as people with dementia (PWD). The temporary closure of day care centres for dementia represented a serious shortcoming in the day-to-day care, with a related increase in stress levels for both PWD and their carers and a reduced quality of life. Within this framework, new non-pharmacological care methods are needed to help reduce agitation-related behaviours in PWD, in order not to increase the pharmacological load and its related healthrisks. This paper presents a pilot study focused on the development of a prototype of a semi-immersive virtual environment, called Semi-immersive Virtual Habitat, aimed at decreasing agitation and enhancing relaxation in PWD, especially after experiencing stressful experiences such as lockdown measures during COVID-19 pandemic.

KEYWORDS | DEMENTIA, SEMI-IMMERSIVE VIRTUAL ENVIRONMENTS, NON-PHARMACOLOGICAL THERAPIES, HABITAT

1. Introduction

1.1 Dementia and COVID-19 Emergency

At the end of February 2019, COVID-19 emergency has raised in Italy. Soon, the whole nation was put into a strict lockdown, and all the population, from young to elderly, had to stop and adapt to the novel measures restricting daily life and social contacts. The effects of lockdown-induced isolation, with changes in daily routines and reduction of emotional, social and physical stimuli, have been a detonator for the rapid increase of neuropsychiatric disorders among those most at risk, such as the cognitively impaired elderly. Among them, people with dementia (PWD), represent one of the most fragile group of people, due to the impairments caused by the disease, and its related symptoms: confusion, agitation, stress-related behaviours, depression and apathy. Dementia is not a specific disease, but a general term describing a wide range of symptoms associated with a decline in memory or other thinking skills severe enough to reduce a person's ability to carry out daily activities. Alzheimer's disease (AD) accounts for 60-80% of dementia cases. Therefore, at the peak of the pandemic, the lockdown triggered another emergency: the increase in neuropsychiatric symptoms, such as agitation-related and stress-related behaviours, in PWD and their families. Agitation-related behaviors include verbal, vocal, or repetitive motor activity (Cohen-Mansfield,2008). Stress-related behaviors include purposeless wander, screaming, repetitive calling out and accelerated breathing (Reynolds et al., 2018). During the lockdown, more than 60% of PWD showed an increase in behavioural disturbances, while more than 65% of family members were found to be more vulnerable and affected by overt symptoms of stress (Cagnin et al., 2020).

1.2 Day-care during COVID-19 Emergency

Strict lockdown measures led to the suspension of all the activities of all semi-residential, socio-assistential, socio-educational, multifunctional, socio-occupational, health and socio-sanitary centres for people with disabilities (comprising physical and mental disabilities, but also people with cognitive impairments such as PWD) given the difficulty of enforcing social distancing rules. The temporary closure of day care centres for dementia represented a serious shortcoming in the day-to-day care of people with dementia, with a related increase in stress levels for both patients and their carers. In general, the most frequently reported symptoms were irritability (40%), agitation (31%), apathy (35%), anxiety (29%) and depression (25%) (Cagnin et al., 2020). Gradually, daily care centers were reopened, once the initial emergency seemed under control. Hence, healthcare professionals had to face the increase of these symptoms affecting the quality of life of PWD, delineating mostly new non-pharmacological methods and therapies, in order not to increase the pharmacological load and its related healthrisks.

1.3 Virtual Reality (VR) Environments as tools in dementia care

Virtual reality (VR) is scientifically understood as a complex environment, determined by a differently immersive, interactive and three-dimensional graphic interface that allows simulation operations and specific forms of communication and learning, offering the user the possibility of perceiving himself as physically present in a virtual world, so that he can interact with it, through sensations, emotions, evaluations and behaviours typical of everyday reality. Among the different types of VR available, this study focuses on the Semi-immersive category, i.e. those VR devices that come in the form of an environmental device, with the size of a small room, equipped with projection or rear projection devices and screens (3 to 6 surfaces) that reproduce the stereoscopic images of the computer and project them on the walls, with different shapes and degrees of convexity, adequate depth indices of the image, giving a three-dimensional effect. To date, there is evidence of the effectiveness of using this tool in various neurorehabilitation fields (Garcia et al., 2012). Moreover, the use of virtual reality environments for PWD is an emerging field, which has shown encouraging positive results in previous research (Flynn et al., 2012; Van Schayk, 2008; Garcia et al, 2012; Reynolds et al., 2018; Kim et al., 2019). In this framework, semi-immersive virtual environments for PWD aim to improve the person's quality of life, decrease the incidence of certain symptoms such as stress, agitation and anxiety and monitor the person's residual capacities. After XXX was put in lockdown due to COVID-19 pandemic, health professionals encountered an increase in those symptoms in PWD. Forced isolation and lack of social interaction had a negative impact on those fragile individuals. Cognitive impairments made difficult for them to understand the occurring situation, increasing their anxiety and behavioural symptoms caused by the lack of assistance due to the closure of socio-assistential services during the lockdown. Thus, semi-immersive VR environment represent a promising tool for dementia care, effective in the decreasing of such symptoms, without increasing the pharmacological load (Kim et al., 2019).

This paper illustrates a pilot study conducted on the effects of using virtual environments on PWD. In particular, the study conducted explores stress-release virtual settings to enhance relaxation in PWD. The research developed the prototype of a Semi-Immersive Virtual Habitat, in the form of an environmental device of 16 sqm (4 meters edge length), aimed at decreasing agitation and stress-related behaviours in PWD.

This study presents an attempt to apply VR technologies in the field of dementia care, especially in the framework of non-pharmacological therapies, aimed at increasing the quality of life of people with dementia. Moreover, COVID-19 pandemic, and the related lockdown measures undertaken in Italy, offer a relevant occasion to experiment this prototype and its therapeutic outcomes, as forced isolation and lack of socio-assistential services led to a heightened need to develop tools and care methods able to lessen stress levels and agitation, and increase wellbeing and quality of life for PWD.

2. VR Environments

According to Ellis (1994), a virtual environment consists of three essential components which, in a transverse manner, integrate with each other:

1) Content: this concerns the quality of reproduction of the virtual objects, which must be as similar as possible to the real ones, having characteristics of staticity and movement, regardless of the user's will or not. In this way, the user has the possibility of integrating with the content, as an agent subject but also as a simple explorer.
2) Geometry: refers to the physical extension that the computer programmer intends to give to the environment, for example closed (a building) or open (a park).
3) Dynamics: this concerns the rules of interaction between all the contents that a designer must bear in mind when creating a simulation. For a virtual environment to be credible, in fact, all the objects contained within it must conform their behaviour to the normal laws of physics of the real world.

Currently, there is evidence of the effectiveness of the use of VR in neurorehabilitation with cognitive impaired people: i.e., in the rehabilitative treatment of memory disorders, both prospective (related to remembering to carry out intentions and actions that cannot be carried out at the very moment they are formulated, but must be postponed to a later time and in a different retrieval context); and recovery, by using the restoring function (repetitive exercises to improve performance in a memory task), for reorganising functions (using the intact function to make up for the damaged one) and to calm states of anxiety or agitation due to neurodegenerative pathologies that impact the person's cognitive abilities.

People with cognitive impairments report decreased stress when using VR for both stimulation and relaxation (Garcia-Betances, 2015). Moreover, individuals with cognitive impairments may positively benefit from the implementation of VR technology care tools which encompass quasi-naturalistic and/or realistic stimuli (Manera et al., 2016).

Thanks to its ability to allow the creation and control of dynamic three-dimensional environments, in which behavioural response can be recorded, measured and improved, virtual environments offer options that are not available with traditional methods (e.g. assessment of cognitive abilities over time, training, sensory stimulation, etc.).

Nowadays, we can discern 2 main categories of VR simulations employed in VR environments: semi-immersive, and fully-immersive ones.

As Persky & McBride (2009) state “Fully-immersive virtual environments allow researchers to create very realistic environments while maintaining a high level of experimental control”. This specific VR technology has been successfully implemented in VR environments aimed at curing phobias, anxiety, stress and memory problems (Garcia, 2012).

Semi-immersive virtual environments are computer-generated environment mainly composed of interactive computer graphics, designed to physically and/or psychologically

immerse one or more users in an alternative reality. This kind of VR Environments can be applied in CAVE-like systems, which generates a room-sized semi-immersive virtual environments with the number of rear-projected bounding surfaces ranging from 3 to 6 (eventually including floor and ceiling).

2.1 Semi-Immersive VR Environments in Dementia Care

Thus, the use of virtual reality environments for people with dementia represents an emerging field, particularly in residential facilities for the elderly, where opportunities to engage residents in a meaningful way may be limited (Siriaraya & Ang, 2014).

VR environments are an emerging technology with a variety of potential benefits for many aspects of rehabilitation assessment, treatment and research in the field of dementia. An interactive and generically immersive virtual environment encourages the creation of virtual but realistic environments for people with dementia, designed with the aim of improving the quality of life of the person living with dementia and monitoring the person's residual capacities (Kim et al., 2019).

Prior studies have explored design requirements when developing VR Environments experiences for PWD in both semi-immersive and fully immersive modalities (Siriaraya & Ang, 2014; Hodge et al., 2018). These studies demonstrated the key role played by VR Environments tailored on PWD preferences and personal interests, as it could enhance a more meaningful engagement (Tabbaa et al., 2019).

In particular, the pilot study presented in this paper, focuses on the development of a prototype of a semi-immersive VR Environment, called Semi-immersive Virtual Habitat, aimed at decreasing agitation and enhancing relaxation in PWD, especially after experiencing stressful experiences such as lockdown measures during COVID-19 pandemic. The semi-immersive Virtual Habitat replicates most of the features of a real-sized CAVE™-like system, allowing health professional to introduce non-pharmacological care methods using virtual reality environments. Moreover, extensive research has examined the important role quality of life plays in the wellbeing of PWD. The environment plays an important role, as it can sustain PWD stimulating correctly their residual capabilities, supporting their loss, and enhancing their independence (Gramegna, 2017). Thus, therapeutic tools aimed at relieving stress and agitation-related behaviours could positively contribute to the enhancement of quality of life for PWD.

3. Semi-immersive Virtual Habitat for dementia care

3.1 Definition of the Habitat

The pilot study presented in this paper is part of a wider research on therapeutic environments for PWD carried out within GRACE_Lab, an experimental laboratory of research involving designers and researchers from Politecnico di Milano and therapists and medical professionals from Genera Onlus, an organization active in the care of PWD in Milan.

The Semi-immersive Virtual Habitat represents the first digital prototype of a virtual therapeutic habitat for PWD developed within GRACE_Lab research.

The Semi-immersive Virtual Habitat physical structure is mainly based on CAVE™ system features and technologies. The first CAVE™ system was designed and built in 1992 by Carolina Cruz-Neira, Daniel J. Sandin, and Thomas A. DeFanti at the University of Illinois, Chicago Electronic Visualization Laboratory (Cruz-Neira et al., 1992). CAVE™ system is a room-sized semi-immersive virtual environment equipped with three to six projected surfaces (eventually including floor and ceiling).

The Semi-immersive Virtual Habitat is a front projected semi-immersive virtual environment which embodies three surfaces for projection and interaction.

The Semi-immersive Virtual Habitat is an interconnected system aimed at stimulating/facilitating cognitive activities involving mainly PWD with Mild and Moderate dementia, and only few with Severe Dementia. Through the use of semi-immersive virtual reality, the Semi-immersive Virtual Habitat creates an interactive environment where PWD can perform cognitive and/or physical activities. In addition, the Semi-immersive Virtual Habitat could represent in the future a dynamic monitoring system of cognitive abilities and a virtual space for rehabilitation activities. At the moment, these possible functions have not yet been tested. Further test and experimentations will be conducted in order to inquiry those aspects and develop a defined protocol of use and evaluation.

The virtual environment is intended to offer different digital configurations in order to create multiple scenarios according to the specific activities (i.e. relaxation, contemplation, cognitive stimulation, etc.) and needs of PWD using the environmental device.

3.2 Habitat Features, Purpose and Interactions

The Semi-immersive Virtual Habitat consists of a physical room enriched with interactive digital projections and tools where PWD, accompanied by therapists can perform therapeutic, contemplative or playful-educational stimulating activities. Inside this virtual environment, researchers adopted a habilitative approach designed to support PWD remaining skills instead of stimulating lost or impaired ones, promoting meaningful and engaging (Brawley,2007; Zeisel,2013; Zeisel & Raia,2000; Zeisel et al.,2003; Reynolds et al., 2018).

These activities are based on the orchestration, in time and space, of appropriate visual, sound, tactile and olfactory stimuli through multimedia projections, lights, sounds, aromas, physical objects (i.e. fabrics). In particular, in the pilot study presented in this paper, designers and researchers developed a collection of digital contents focused on the interactive projection of natural environments, natural elements, animals and outdoor natural environments (i.e. reproduction of woods with hidden interactive animals, woodlands and seascapes), as promising, but still hardly explored, therapeutic elements to foster relaxation in PWD. According to Reynolds et al. (2018) “Research has found that viewing nature reduces stress and improves mood, but few studies have focused on the potential of viewing nature to reduce negative emotions associated with dementia”. Previous studies underline how direct contact with nature has a positive outcome on PWD mood and wellbeing (Zeisel,2013; Zeisel & Raia,2000; Zeisel et al.,2003). Nature and in particular, gardens and woodlands represent an effective and evidence-based approach to reduce agitation-related and stress-related behaviours in PWD (Zeisel, 2013; Reynolds et al. 2018). Several studies described the benefits of viewing natural scenes and natural landscapes on PWD. This supports the hypothesis that also experience a virtual natural landscape may reduce stress-related and agitation-related behaviours among PWD. The specific purpose of this study was to understand whether a virtual natural experience could reduce stress and agitation, enhancing relaxation, in PWD attending a daily care center, after a stressful experience such as the lockdown occurred in Italy in 2020 due to COVID-19 pandemic.

3.3 Habitat Experience

Specifically, the pilot study conducted, involved a group of 30 PWD attending a day care center in Milan. Participants ranged in age from 70 to 83 years, involving both women and men. Moreover, participants were experiencing stress-related and/or agitation-related behaviours. Two alternate 30-minutes sessions were conducted with each group. Previously, all the persons involved undertook a mini-mental state exam (MMSE). The MMSE was used to provide an overall picture of cognitive status and dementia severity and produced a range from 9 to 25 where lower scores correspond to greater dementia severity (Folstein et al., 1975). Participants were divided into two groups, both of them covering Mild, Moderate and Severe dementia. Each group experienced alternatively the virtual environment during a 30-minutes session, in which therapists alternated contemplative views and short interactive activities. Initially, an introductory phase was conducted by the therapists: they asked to the participants to describe the view they were seeing, which kind of elements they could discern, if they liked it or if they were scared. Afterwards, therapists conducted short question-based activities, supported by interactive projections taking place in the Semi-immersive Virtual Habitat. Some of them encompass the contemplation of natural sceneries, associated with sounds and odours. In the end, therapists proposed to the participants to directly and freely interact with the projections.

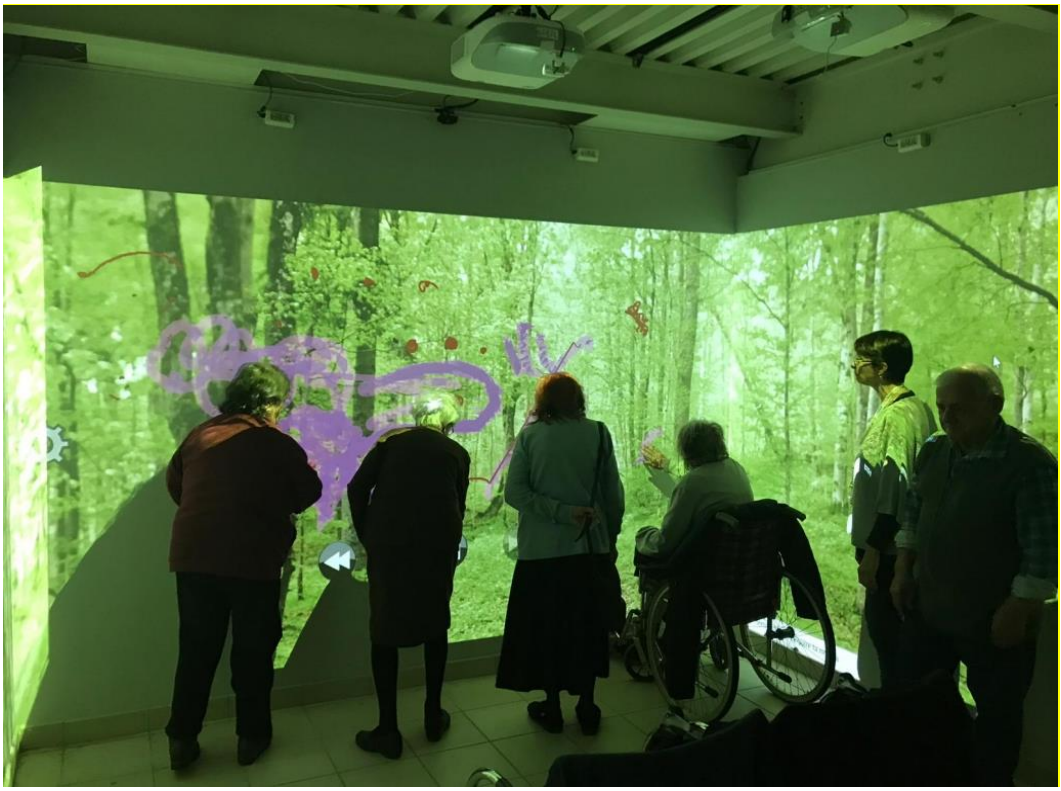

Fig.1: Pilot study participants spontaneous interaction with Semi-Immersive Virtual Habitat

4. Outcomes

Design researchers participated in the sessions as observers. Comments and gestures (in the form of body positions, non-verbal gestures and communications, movements) made by participants were analyzed to understand the overall reactions. In particular, the sessions were audio recorded, in order to be further analysed by the research team, giving special emphasis to the comments made by the participants during the different interactions. Comments made during the sessions were associated with discomfort, agitation, pleasure, relaxation, with supplementary observations regarding reminiscing factors and past life events. Comments made by the participants associated with discomfort and agitation were “I don’t like this place”, “What’s wrong here”, “I don’t like it”, in a single case accompanied by gestures such as searching for an exit wandering purposelessly around the room. Comments associated with pleasure encompassed “how beautiful is here”, “wonderful”, “I like these trees”, “I feel good”. Often these comments were associated with facial expressions indicating enjoyment and astonishment, hand gestures and non-verbal expressions indicating positive amazement. Relaxation was detected from body positions and gestures: some participants assumed a more relaxed position while seated on the chairs, one participant fell asleep during a natural scenery contemplation activity. During the sessions, some participants reminisced about past experiences sharing comments like “I

have been there", "when I was young I went there with my family", "With my wife we liked walking in the mountains". To resume the comments made by participants during the sessions, there were 6 comments related to discomfort, 3 comments related to agitation, 22 to pleasure, 4 related to reminiscence. Regarding the participants, during the sessions, one person expressed agitation-related behaviours, wandering around purposelessly. Another person expressed discomfort. None of the participants expressed apathic behaviours. 28 participants out of 30 expressed interest and/or positive mood. Among them 24 undertook body positions expressing relaxation and comfort. 1 participant fell asleep during the session. We could discern 2 kinds of behaviours among the participants: on one hand, active participation accompanied by curiosity for the interactions taking place, on the other hand, contemplation and amusement for the virtual sceneries. The last part of each session was dedicated to free interactions with the digital environment: 28 participants out of 30 spontaneously interacted with the digital environment through gestures associated with verbal comments. Those comments include "That's wonderful, you can draw without getting dirty", "look at the flowers I'm drawing", "I like it".

After the sessions, therapists asked to participants to describe their mood. 28 participants made positive comments like "I feel good", "I enjoyed it", "I'm fine and I liked it". Therapists noticed that the majority of the participants were calm, without expressing agitation-related behaviours. Moreover, 11 participants fell asleep after the sessions.

5. Discussion and Limitations

The pilot study was conducted with a small sample of participants due to the limited number of PWD attending the day care center involved in this research. Recruiting more participants for the study was not possible, given the maximum attendance of 35 patients in the day care center. Taking into account this limitation, the results are promising, and a sample size of 30 represents a statistical significance in this pilot study. Accordingly, future studies with larger sample sizes have the potential to show results even more significant.

Previous research supports the benefits of direct contact with nature on hospitalization (Ulrich et al., 1991; Rodiek, 2006), and moreover on PWD (Brawley, 2007; Calkins, 2011). Virtual environments have been extensively used in the treatment of agitation in people with cognitive impairments (Garcia-Betances, 2015), while little research has been conducted on the positive effects of virtual environments on PWD (Siriaraya & Ang, 2014), making this specific topic a promising field of research. This pilot study, gives support to the hypothesis that a virtual experience of natural scenes may enhance relaxation and positive mood, reducing agitation-related behaviours in PWD exposed to a stress period.

From the pilot study conducted it is possible to deduce that a VR semi-immersive experience, focused on the projection of natural environments, significantly improved relaxation and pleasure in PWD involved. Pleasure comments and the lack of agitation-

related and stress-related behaviours underline the positive outcomes of such virtual experience on PWD.

Key findings of this pilot study are that semi-immersive virtual environments positively affect the majority of the participants, with only 2 of them expressing increased agitation or discomfort. Pleasure and positive mood were clearly identified among the majority of the participants. The analysis undertaken during and after the sessions represented an initial attempt to evaluate qualitatively the mood and the state of relaxation among participants. All the participants involved were showing agitation-related and stress-related behaviours before being involved in the semi-immersive virtual sessions. Their spontaneous interactions with the virtual environment may represent that semi-immersive virtual environments could be considered effective tools in the care of PWD. Moreover, the participants who fell asleep after the sessions, may represent a significant sign of the effectiveness of such experiences in enhancing the relaxation of stressed PWD without using pharmacological interventions.

Recommendations for future research regard the involvement of a larger sample of participants, in order to strengthen the efficacy of the study. The collection of data in the form of comments through the use of a video camera may reduce the influence of the presence of a researcher in the room, which could have influenced the emotions and behaviours of some of the participants, and so could have represented a limitation to the study. Further analysis may be conducted on the potential correlations between the severity of dementia (Mild, Moderate or Severe dementia), the type of comments and interactions performed with the virtual environment.

Actually, the ongoing sanitary emergency prevented the researchers to perform further studies, as social distancing measures were recently reintroduced in Italy. The introduction of heart rate monitoring before and after joining the session in the Semi-Immersive Virtual Habitat would represent a significant measure to effectively quantify stress in the participants, associated with agitation-related behaviours. Another future significant implementation could be the use of eyes tracking technologies in the Semi-immersive Virtual Habitat architecture, in order to detect clear signs of agitation among the participants.

6. Conclusions

The pilot study presented in this paper has a dual purpose: on one hand, to examine the effectiveness of a semi-immersive virtual experience on PWD experiencing agitation-related behaviours. On the other hand, this pilot study inquiries the effectiveness of a natural virtual experience on PWD, and its capability to reduce stress-related behaviours. Literature underlines that direct contact with nature should be preferred, but some studies started to explore the effectiveness of virtual natural experiences. The Semi-immersive Virtual Habitat presented in this pilot study could be considered a promising tool for enhancing relaxation in PWD experiencing agitation, stress and anxiety. The semi-immersive virtual experience provided showed positive results in reducing agitation. A virtual space could offer a cost-

effective solution in the hands of therapists to reduce stress in PWD, without recurring to pharmacologic treatments. As Alzheimer's Association (2015) reports, new treatment strategies are needed to help reduce pharmacologic interventions and their associated healthrisks.

New therapeutic tools such as the Semi-Immersive Virtual Habitat presented in this pilot study, represent promising tools for the enhancement of the quality of life of PWD, especially after experiencing stressful life events such as lockdown and social distancing mesures, as happened in 2020. Effective non-pharmacological tools and therapies may promote positive mood and relations among PWD, staff and family members involved, and may improve PWD involvement in meaningful and pleasurable activities (Livingston et al., 2014).

The Semi-Immersive Virtual Habitat presented in this pilot study is not meant to be a stand-alone intervention, but rather needs to be integrated into a complete care management program, tailored on the individual's needs.

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