Chapter

The Complexity of Frailty: Psychological Mechanism and Therapeutic Interventions in Old People - A Narrative Review

Francesca Romana Greco and Grazia D'Onofrio

Abstract

Aging is a complex and dynamic process. Senses become less sophisticated and negative life events increase. These factors combined with medical conditions contribute to develop a degenerative functional autonomy of the elderly. This clinical condition is known as frailty. However, there is a difference in the way people live their silver years in terms of happiness and their sense of autonomy. Both being and feeling frail represent two different drives of cognitive representations concerning how the elderly live their lives. In addition, other factors such as cognitive stimulation, assistive technology and physical activity can support frail people to achieve independence. This chapter aims to provide an overview on how the psychological environment may affect frailty, suggesting a possible role of new technology's solutions and physical activity as therapeutic interventions.

Keywords: aging, frailty, emotion, assistive technology, psychology

1. Introduction

Aging is commonly defined as the accumulation of many deleterious changes in cells and tissues with advancing age that are responsible for the increased risk of disease and death (see **Table 1**) [1]*.

As a consequence of the extended life expectancy, older population is rapidly increasing all over the world [2].

Older adults may experience reduced mobility, chronic pain, frailty, major neurocognitive disorder and many other health problems affecting the quality of their life.

Furthermore, all these factors can lead to social isolation, loneliness or physical distress that may require long-term care [3]*.

To date, a great amount of data exists on frailty in older people, but few and conflicting data exist about the psychological mechanism of frailty and its preventability.

This narrative review aimed to analyze to which extent the psychological setting may improve frailty condition in elderly people.

This chapter also aimed to present a brief description of the main psychological models and interventions used in the clinical practice for the elderly.

Frailty: Frailty can be defined as a 'clinically recognizable state of increased vulnerability resulting from aging associated decline in reserve and function across multiple physiologic systems such that the ability to cope with everyday or acute stressors is compromised
Comprehensive Geriatric Assessment (CGA): It is defined as a multidisciplinary diagnostic and treatment process that identifies medical, psychological and functional limitations of a frail person in order to develop a coordinated plan to maximize overall health with aging.
Cognitive impairment: Cognitive impairment is when a person has trouble remembering, learning new things, concentrating, or making decisions that affect their everyday life. Cognitive impairment ranges from mild to severe. With mild impairment, people may begin to notice changes in cognitive functions, but still be able to do their everyday activities. Severe levels of impairment can lead to losing the ability to understand the meaning or importance of something and the ability to talk or write, resulting in the inability to live independently.
Emotions: biological states associated with the nervous system brought on by neurophysiological changes variously associated with thoughts, feelings, behavioral responses, and a degree of pleasure or displeasure. There is currently no scientific consensus on a definition. Emotion is often intertwined with mood, temperament, personality, disposition, creativity and motivation.
Positive technology approach: is a scientific and applied approach to the use of technology for improving the quality of our personal experience through its structuring, augmentation and replacement

Table 1.
Definitions.

Furthermore, we proposed a positive technology approach in order to assist elderly people using new technology solutions [4].

2. Methodology

We searched for publications dated between January 2015 and January 2020 (see **Table 2**) using keywords and medical subject headings termed as psychology of frailty in the elderly. We searched PubMed, Medline and Google Scholar database.

Figure 1 shows the flow chart selection process. From the 1648 papers initially selected, 20 were found suitable to be included in the present review (**Table 3**).

2.1 Possible limits of the review

Some possible limits of this narrative review can be found in the low prevalence of randomized clinical trial that has investigated classical or innovative psychological intervention for the frailty in elderly people.

3. Discussion

3.1 The complexity of frailty syndrome

Life expectancy has rapidly increased worldwide, from 461 million people older than 65 years in 2004 to an estimated of 2 million people by 2050 [5].

This has a severe impact on social care.

In addition, frailty is the most problematic expression of population aging because it is strictly interrelated to the physical system such as the endocrine, muscle, cognitive and respiratory.

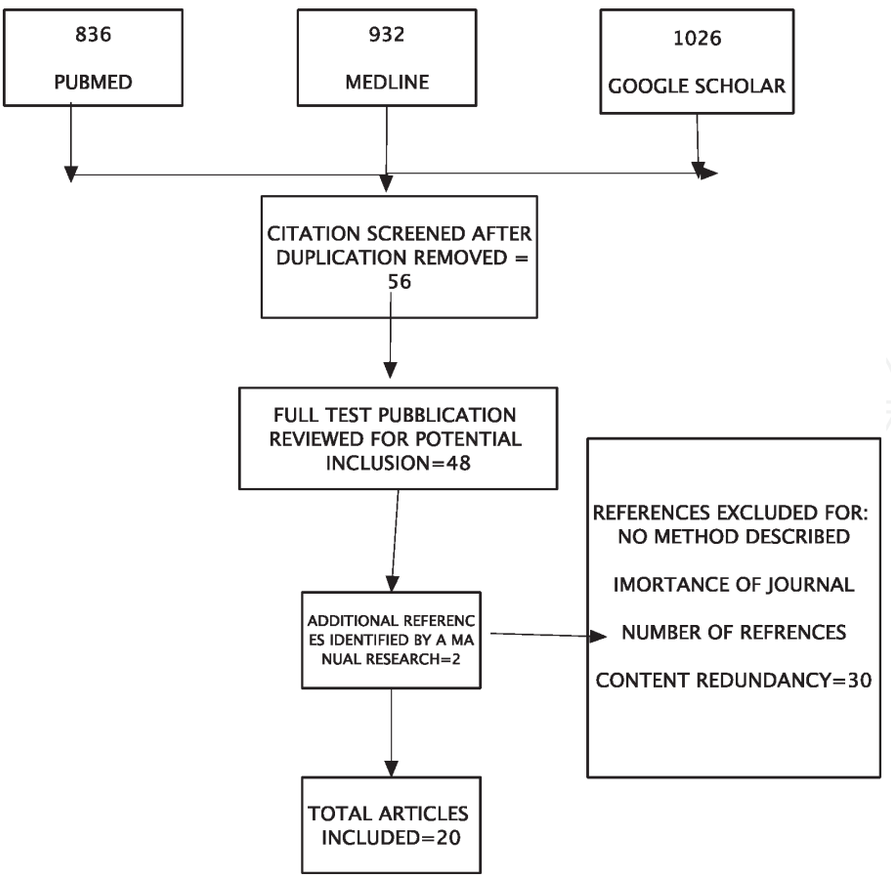

Table 2.
Flow chart of the literature selection.

Figure 1.
Examples of casual and hardcore video games.

*Ref.	Title	Authors	Therapeutic approach	Duration of intervention	Characteristic of the sample	Succes/failure of the intervention
1*	*Frailty measurement in research and clinical practice: A review*	Elsa Dent, Paul Kowal, Emiel O. Hoogendijk, 2016.	Review	January 2009-July 2015	422 studies were identified. From these studies, 29 different frailty measurements were included.	The CHS index is the most robust assessment tools for use by clinicians and researchers today.
3*	*Interventions aimed at loneliness and fall prevention reduce frailty in elderly urban population*	Sanja Ožic et al; 2020	Prospective interventional study	January 2015-September 2017	410 persons aged 75 to 95	Public health interventions to prevent falls and to prevent loneliness have a positive effect on the frailty and independent living of the elderly living in their own homes in an urban community.
37*	*Which one came first: movement behavior or frailty? A cross-lagged panel model in the Toledo Study for Healthy Aging*	Asier Mañas, Borja del Pozo-Cruz, Irene Rodríguez-Gómez,et al; 2020	Longitudinal study	Over 4 years	186 older people aged 67 to 90	MVPA/SB and frailty is unidirectional: individuals who spent less time on moderate to vigorous physical activity are more likely to increase their frailty score, and individuals who are more frail are more likely to spent more time on sedentary behaviour.
23*	*Frailty is associated with early hospital readmission in older medical patients*	Gary R. Stillman, Andrew N. Stillman and Michael S. Beecher. 2019	Retrospective analysis	Between September 2017 and June 2018	435 patients over 65 years	Frailty as measured by the Reported Edmonton Frailty Scale was a significant predictor of hospital readmission and length of stay.
13*	*Incidence and Predictors of Cognitive Frailty Among Older Adults: A Community-based Longitudinal Study*	Nurul Fatin Malek Rivan et al; 2020	Community-based longitudinal study	5 years follow-up	Out of 490 older adults participating in the Malaysian Towards Useful Aging (TUA) study, 282 were successfully followed-up at five-years for an analysis of the CF incidence.	The incidence rate of Cognitive Frailty was 7.1 per 100 person-years. Advancing age, depression, decreased processing speed, assessed by a lower digit symbol score decreased functional mobility measured using Timed-Up-and-Go (TUG) low vitamin D intake and physical frailty were predictors for CF incidence
17*	*Anticipatory care planning intervention for older adults at risk of functional decline: study protocol for a primary care cluster feasibility randomised trial*	Kevin Brazil et al; 2020	Cluster randomised controlled trial	The study started in April 2019.	A total of 64 patients > 70 years	Evaluation of the implementation and outcomes of an ACP intervention to identified the risk of functional decline.
33*	***Functional Ability, Frailty and Risk of Falls in the Elderly: Relations with Autonomy in Daily Living***	**Inmaculada Tornero-Quiñones, Jesús Sáez-Padilla, Alejandro Espina Díaz, Manuel Tomás Abad Robles and Ángela Sierra Robles. 2020**	**Cross-sectional investigation study**	**Not specified**	**A total of 139 elderly**	**Functional capacity is a significant predictive variable of autonomy in instrumental activities of daily living, while fragility and the risk of falls are significant predictors of autonomy in activities of basic daily life.**

38*	*Association between frailty and the combination of physical activity level and sedentary behavior in older adults*	Venicius Dantas da Silva et al; 2019	Cross-sectional study	Data collection for the present study occurred from July to October 2015	457 older adults (age range = 60 to 96 years old)	Frailty is more prevalent among older adults who exhibit insufficient levels of physical activity combined with a great amount of time spent in sedentary behavior, even when adjusted for socio demographic factors.
30*	*The relationship between basic, instrumental, and advanced activities of daily living and executive functioning in geriatric patients with neurocognitive disorders*	Elise Cornelis,Ellen Gorus, Nele Van Schelvergem, Patricia De Vriendt. 2018	Correlational study	Not specified	One hundred twenty participants (80 female and 40 male) were included	This study recommends using the TMT-A, CDT, and AFT as screening tools to indicate the need for profound evaluation of ADLs in older persons with neuro cognitive disorders.
43*	*"Homeless in life" loneliness experienced as existential suffering by older adults living at home: a caring science perspective*	Jessica Hemberg, Fredrica Nyqvist, and Marina Nasman. 2018	A qualitative study	Not specified	A total of 17 participants (12 females and five males) aged 72–95 years in different life situations	Enhancing the quality of life for vulnerable individuals by supporting older adults in strengthening their health, communion with others and engaging them in meaningful social activities in daily life. This study also sheds light on the complexity of loneliness; being socially lonely does not automatically mean suffering from loneliness.
11*	*Frailty predicts mortality in all emergency surgical admissions regardless of age. An observational study*	J. Hewitt, B. Carter, K. MC Carthy.et al. 2019	multi-centre prospective cohort study	The study was carried out during 2015 and 2016	2,279 patients	Worsening frailty at any age is associated with significantly poorer patient outcomes, including mortality in unselected acute surgical admissions.
24*	*Depression in older adults*	Amy Fiske, Julie Loebach Wetherell, and Margaret Gatz. 2009	Review	Not specify	Older adults	Depression is less prevalent among older adults than younger adults. Older adults are more likely to display cognitive changes, somatic symptoms than younger adults. Support the use of psychological and somatic interventions to prevent the onset of depression in later life.
16*	*Multicomponent Frailty Assessment tools for older people with psychiatric disorder: A systematic review*	Jennifer L. Sutton, Rebecca L. Gould, Mark C. Coulson et al. 2019	A Systematic Review	2017	Adults aged 60 years or older	No frailty assessment tool identified in this review was developed for use with, nor had its reliability or validity been tested in older adult psychiatric populations.
52*	*Virtual enactment effect on memory in young and aged populations: A systematic review*	Cosimo Tuena, Silvia Serino, Léo Dutriaux, Giuseppe Riva and Pascale Piolino. 2019	A Systematic Review	25 January 2019	Majority of the experiments included healthy participants, mainly young adults (YA), but also older adults (OA)	The present review sheds light on the key role of the sensorimotor and cognitive systems for memory rehabilitation by means of a more ecological tool such as virtual reality and stresses the importance of the body for cognition, endorsing the view of an embodied mind.

44*	*A Social Virtual Reality-Based Application for the Physical and Cognitive Training of the Elderly at Home*	Sara Arlati, Vera Colombo, Daniele Spoladore, et al. 2019	A validation study that provides frails elderly with a dual task training program	2019	Frail elderlies	The final aims are reducing the risk of falling, through the improvement of the clinical outcomes of frailty, and promoting their social participation.
9*	*Frailty Clinical Phenotype: A Physical and Cognitive Point of View*	M Aubertin-Leheudre, AJ Woods, S Anton, R Cohen, and M Pahor. 2015	Manuscript based on the definition of frailty	Not specified	Frailty and elderly people	Frailty can present in different stages of severity (from mild to severe), and there appears to be a dynamic relationship between these stages. Despite these challenges, a consensus on an international definition of frailty including physical and cognitive criteria is essential in order to advance research and treatment of this condition.
31*	*Depression, frailty, and all-cause mortality: a cohort study of men older than 75 years.*	Almeida OP, Hankey GJ, Yeap BB, Golledge J, Norman PE, Flicker L. 2015	Prospective longitudinal cohort study	2008	2565 men aged 75 years	Current, but not past, depression is associated with increased mortality, and this excess mortality is strongly associated with frailty. Interventions designed to decrease depression-related mortality in later life may need to focus on ameliorating frailty in addition to treating depression.
21*	*Expert opinion on the management of pain in hospitalised older patients with cognitive impairment: a mixed methods analysis of a national survey.*	Rodger KT, Greasley-Adams C, Hodge Z, Reynish E. 2015	A mixed methods analysis of a national survey	Not specified	consultant Geriatricians/Dementia Leads identified in the National Dementia Audit from the British Geriatrics Society	The need for evaluation of the whole individual (a Comprehensive Geriatric Assessment approach), including their family and care- givers and the environment are promoted rather than an approach that would just simply treat the pain.
32*	*Social vulnerability and survival across levels of frailty in the Honolulu-Asia*	Joshua j. Armstrong, Melissa k. Andrew, Arnold Mitnitski, Lenore j. Launer, Lon R. White, Kenneth Rockwood. 2015	Self report approach	From 1991	Sample of 3,271 older men	- Changes in the health of individuals result from both intrinsic and extrinsic factors, such as social vulnerability. -The impact of social vulnerability on mortality differed across frailty groups. -For frail individuals, intrinsic factors influenced mortality risk more than extrinsic factors.
19*	*Fried phenotype of frailty: cross-sectional comparison of three frailty stages on various health domains.*	Linda P. M. Op het Veld, Erik van Rossum, Gertrudis I. J. M.Kempen et al; 2015	Cross-sectional study	2012	8,684 community-dwelling older people (65+)	This study indicated that the Fried frailty criteria could help healthcare professionals identify and treat frail older people in an efficient way, and provide indications for problems in other domains.

Table 3.
Summary of the included studies.

From this background, two models were proposed in order to identify the concept of frailty in elderly patients.

Rockwood and colleagues have defined frailty as an accumulation of deficits.

One such example is the risk to develop dementia which increases in relation to problems with hypertension or diabetes in older adults [6].

It is becoming clear that a range of subclinical and clinical age-related deficits, which are themselves not recognized as disease-specific risks, are associated with a greater chance of common age-related illness in older adults [7].

On the other hand, the phenotype model suggests that five factors (weight loss, self-reported exhaustion, low-energy expenditure, slow gait speed, and weak grip strength) are associated with frailty [8].

What does it means being frail? And what characteristic defines a frail person?

Aging is arguably the most familiar yet least well-understood aspect of human biology, and it can be present in different stages of severity: From mild to severe [9]*.

It is characterized by a progressive impairment of functions, difficulties in environmental challenges, and a growing risk of death.

Clinicians suggest that frailty is a state of vulnerability in front of a stressful situation, and the consequences are a decline in health status [10].

Therefore, the risk of developing other negative life events including falls, delirium (a temporary condition characterized by the rapid onset of fluctuating confusion and impaired awareness) and disability could increase.

To date, the concept of frailty is well analyzed in the clinical setting, where it is considered as a potential negative factor of the patient's clinical condition.

J. Hewitt and colleagues suggested that frail patients are likely to stay in the hospital longer than those that are not frail.

In fact, there is a linear relationship between the increase of clinical frailty index at admission and increase odds of day 90 mortality [11]*.

Frailty in old people becomes also evident in many complex physiological systems including cognitive functions.

Aging is characterized by structural and physiological changes in the brain.

The loss of individual neurons in most cortical regions is low, but neurons with high metabolic demands, such as the hippocampal pyramidal neurons, could be affected disproportionally by changes in synaptic function.

The hippocampus has been identified as an important mediator in the pathophysiology of cognitive decline and Alzheimer's disease, and it is a key component of the stress response.

The aging brain is also characterized by structural and functional changes to microglial cells, which have an important role in the pathophysiology of delirium [12].

Accumulated evidence supports an association between frailty, cognitive impairment, dementia and Alzheimer's disease [13]* [14].

In a prospective, observational cohort study, Boyle et al. show the hypothesis that physical frailty is associated with an increased risk of mild cognitive decline in aging [15].

In this study, more than 700 older people without mild cognitive impairment were involved.

Physical frailty, based on four components (grip strength, timed walk, body composition and fatigue) was assessed at baseline and cognitive function was assessed annually.

Proportional hazard models were used to examine the association of physical frailty with the risk of incident MCI, and mixed effect models were used to examine the association of frailty with the rate of change in cognition.

During up to 12 years of annual follow-up, 305 of 761 persons developed MCI. Moreover, a higher level of physical frailty was associated with an increased rate of decline in global cognition and five systems (episodic memory, semantic memory, working memory, perceptual speed and visual spatial abilities).

In addition, Jennifer and colleagues have evaluated the use of multicomponent frailty assessment tools in assessing frailty also in elderly patients with psychiatric

disorders, comparing the items of each frailty assessment tool with the *Diagnostic and Statistical Manual of Mental Disorder 5th Edition* (DSM-5) criteria to assess the overlap.

The results suggested that there is a significant overlap between the indicators of frailty as conceptualized in frailty assessment tools and DSM-5 diagnostic criteria for a common psychiatric disorder including major depression episode and generalized anxiety disorder that has the potential to confound frailty assessment results [16]*.

3.1.1 Evaluation tool

In order to establish frailty, reliable models should be assessed for their success in predicting therapeutic interventions [17]*.

As we previously described above, there are two main geriatric models: The phenotype model [8] and the cumulative deficit model, which form the basis of the Canadian study of health and aging (CSHA) frailty index [18].

This chapter aims to go deep under the knowledge of these models and explore how do these models are used in the clinical practice.

A frailty phenotype was established with five variables: Unintentional weight loss, self-reported exhaustion, low-energy expenditure, slow gait speed and weak grip strength.

The Fried frailty criteria could help healthcare professionals to identify and efficiently treat frail older people in an efficient way and also contribute to provide indications for other related problems (social, psychological and physical functioning).

In a study of 5210 men and women aged 65 years and older, Fried and colleagues conducted a famous study that is known as the milestone study of the phenotype model [19]*.

A frailty phenotype was established with the five variables: Unintentional weight loss, self-reported exhaustion, low-energy expenditure, slow gait speed and weak grip strength.

People with Parkinson's disease, previous stroke, cognitive impairment or depression were excluded.

Those with three or more of the five factors were judged to be frail, those with one or two factors as pre-frail and those with no factors as not frail.

This work is important because it suggests that a frailty phenotype can be defined and might be a basis for detection of frailty in routine care.

However, how the variables can be reliably translated into clinical practice is not clear.

Furthermore, other important factors such as cognitive impairment, a prevalent condition associated with functional decline, were not included as part of this model.

Despite the criticism, the general approach of clusters of variables to define frailty phenotype has been independently validated.

The frailty index was developed as part of the CSHA study [18].

10,263 people were involved, and it was designed to investigate the epidemiology and burden of dementia in elderly people in Canada.

92 baseline variables of symptoms (e.g. low mood), signs (e.g. tremor), disabilities and abnormal laboratory values (referred to as deficits) were used to define frailty.

The frailty index was a simple calculation of the presence or absence of each variable.

The frailty condition is defined as the cumulative effect of individual deficits.

Additionally, the cumulative deficit model expresses the theory of a gradation of frailty with progressive accumulation of deficits.

This model is clinically attractive because it presents frailty as gradable, rather than present or absent.

3.2 Comprehensive geriatric assessment

Clinicians and researchers need valid and accurate methods to assess and identify frailty.

Comprehensive geriatric assessment (CGA) [20] (see **Table 1**) has become an internationally established method to assess elderly people in clinical practice.

This method is the goal standard to assess frailty.

It is a process that specializes the elderly care delivered by a multidisciplinary team (psychologists, nurses, occupational therapists, and geriatricians) to establish functional psychological functions and a plan of treatment [21]*.

Besides, as aging is a process that leads to conditions of vulnerability to mortality and severe stress, also for the caregiver's multidisciplinary approach, programs of prevention should be proposed.

How do clinicians identify frailty in the clinical practice?

More specifically, many types of test are used to evaluate the state of frailty in elderly people.

Among them, the timed up and go test (TUG) and the Edmonton Frail Scale are commonly used for screening the evaluation of frailty.

The TUG test is a simple and specific method to test functional mobility.

This test is easily included as part of the routine medical examination.

This test assesses many dimensions of frailty and requires no specific equipment or training.

Each singular patient is observed and timed, while he/she rises from an armchair, walks 3 m, turns, walks back, and sits down again.

The results indicate that the "up and go" test is a valid test to quantify frailty [22].

Moreover, the Edmonton Scale is a multidimensional scale assessment instrument that includes the timed up and go test and many other tests in order to evaluate cognitive impairment (see **Table 1**).

The test lasts less than 5 minutes and is a valid instrument.

To underlie the negative effects of frailty and the use of Edmonton Frail scale as a multidimensional assessment, an original study was conducted.

Beecher MS and colleagues conducted a retrospective analysis based on 435 elderly patients.

This study aimed to evaluate the probability of early readmission and length of hospital stay, using the Edmonton Scale and the age-adjusted Charlson comorbidity index.

The results suggest that the Edmonton Scale was a significant instrument to predict hospital readmission and length of stay [23]*.

4. Emotion and frailty

Social isolation or being socially lonely could have a severe impact on the psychological health of the elderly.

Therefore, it is necessary to support the elderly in order to prevent them from mood disorders.

Importantly, depression merits special attention because it can have negative consequences, including increased burden of physical illness, cognitive impairment and risk of suicide [24]*.

Living alone, not having a friend to confide in and not spending time with others could have a severe impact on psychological well-being.

Being both active and socially involved are very important for frail patients; therefore, emotions (see **Table 1**) and affective recognitions may play a crucial role during aging.

Moreover, neuropsychological functions are strictly connected with perceptions of satisfaction of life and emotion recognition.

To date, existing literature suggests that age affects emotion recognition.

Does aging affect emotion detection during their life span?

Being socially involved in a relationship, cooperating with others, understanding and reacting appropriately to the social signals sent out by other people determine social perception abilities.

Being able to decode emotional expressions is an important and essential skill to navigate through the social world and to guide appropriate behavior.

Meyer and colleagues propose that social perception is a powerful dimension of emotional intelligence as mental ability including personal and social intelligence [25].

Prosocial behavior is involved in being able to establish a social relationship [26].

However, old people respond differently to emotional stimuli in everyday life.

Little is still known about the emotion recognition of the elderly and how these are linked with the changes in social life during the life span of people.

Ruffman and colleagues examined 60 young and 61 older adults' recognition of emotions in facial, vocal, bodily expression and when matching faces and bodies to voices.

Older adults were worse than young adults, reporting difficulties in recognizing both positive and negative vocal and bodily expression.

In addition, they found that older adult's difficulty in matching emotions was explained by an additional problem of integration [27].

Social perception is a key factor to understand and react at the social signal sent out by other people.

Also, as people grow older, they prioritize close social relationships and focus more on achieving emotional well-being; therefore, the elderly became more selective in what and in where they invest their emotional resources.

It should be noted that most emotions that are decoded from people are not static but dynamic.

Dynamic facial cues improved recognition of facial emotions for both younger and older adults.

In addition, these results could also explain why many elderly have difficulties to recognize emotion which appear stable [28].

Neuroscientists suggest that also gender differences could be involved in emotional regulation and recognition of emotions.

More specifically, the amygdala is essential for enhanced long-term memory associated with emotional events.

There is a strong relationship between men and women in the activity of the right hemispheric of the amygdala and memory functions regarding emotional material [29].

4.1 Cognitive compensatory strategies in ageing

During aging, the old people could be affected by cognitive impairment and dementia disease.

This means that many cognitive domains like attention, memory and also mood state could be affected [30]*.

The relationship between depression and frailty remains one of the common problems of the elderly [31]*.

Besides, many changes in the health of elderly result from both intrinsic and extrinsic factors, such as social vulnerability [32]*.

However, cognitive declines take place over a long time, and during this lapse of time, the elderly can adopt to many cognitive strategies to manage stressful

situations (e.g. cooking, providing self-care, etc.), while fragility and risk of fall are two negative predictors of well-being [33]*.

Many researchers from France conducted an innovative study on this topic, comparing the drivers' performances on a driving simulator between 12 elderly (between 65- and 78-year-olds) and 18 younger people (between 21- and 35-year-olds) [34].

They compared their self-assessment of driving as well as their visual and cognitive strategies.

Finally, they assessed their driving competencies and self-regulation practice using a simulator.

This research sheds some additional point on the ability to self-regulate the behaviors of the elderly, which could reduce the risk of being injured and to prevent from social isolation, for example, increasing the safety distance from the vehicle in front when reflexes decrease.

Previous research on this matter found that elderly drivers self-regulate by engaging less frequently in secondary tasks (singing or talking) when the driving task is more difficult.

In this way, they reduce the cognitive cost of sharing attention between two tasks [35].

More specifically, in older people, cognitive strategies are used to solve problems of daily life living.

Being able to self-regulate our mood state and cognitive functions is essential to make sense and meaning of life.

Furthermore, the ability to reflect on how important it is to live these silver years in terms of happiness and quality of life could have a great impact on the subject of well-being.

Therefore, understanding and enhancing these cognitive strategies could be crucial to support people in developing many coping methods.

In addition, a positive technology approach could be useful to identify and solicit cognitive competencies.

5. Positive technology for healthy living and active ageing

"Positive technology" (see **Table 1**) approach is a scientific and applied approach to the use of technology for improving the quality of our personal experience through its structuring, augmentation and replacement [36].

Aging is associated with a decline in mental, physical, functional activity and well-being; therefore, it is necessary to promote active behavior in contrast to sedentary behaviors [37]*, [38]*.

However, promoting well-being in old people lifestyle interventions is commonly used to improve their quality of life.

Furthermore, technology could have an important role in supporting elderly living and healthy and active aging.

Developing technological systems and applications to promote personal growth, creativity and social support should be done by psychology.

Specifically, positive psychology is a psychological approach, which focuses on the biopsychological aspects of cognitions, emotions and positive experiences [39].

Martin Seligman is considered as the pioneer of positive psychology.

He identified "three pillars" of the good life in his book titled *Authentic Happiness* [40]*:

- The pleasant life: Achieved through the presence of positive emotions.

- The engaged life: Achieved through pleasant activity.
- The meaningful life: Achieved through the ability to discover meaning and a purpose in life.

According to positive psychology, positive technologies are classified in three dimensions [41]:

- Hedonic dimension: Technologies are used to induce positive experiences.
- Eudaimonic dimension: Technologies are used to support people in reaching engaging and personal experiences.
- Social/interpersonal dimension: These types of technologies are used to improve social integration and be part of a social group providing relational well-being.

The use of positive technology brings an advantage in cognitive stimulation technologies beyond traditional healthcare.

In virtual reality, the serious game could engage the attention of the elderly.

In addition, thanks to a positive technology approach, it is possible to change from a "disease-centered" to a "citizen-client" model, based on the engagement of the elderly [42].

5.1 The effect of technology interventions on reducing social isolations

Social isolation is one of the major risk factors of mental and physical health for the elderly [43]*.

However, many authors have investigated the role of technology as a new potential intervention to prevent social isolation.

Assistive technology could contribute to improving their quality of life, living independently at home.

Assistive technology includes many devices, which support people in their independent living [44]*.

To date, smartphone and smart applications are the most common device involved in assistive technology [45].

Using smartphone includes many advantages: Flexibility, user friendly, various built-in sensors and connectivity options.

These technological devices make possible the development of new solutions for the elderly.

Going deep under the use of technology, several studies proposed the role of video games as powerful tools for cognitive training and well-being of the old people.

In fact, during the past years, video games were not designed to support people or for specific improvements on cognitive domains, but recent research finds out that they could be a valid instrument to help people with specific cognitive training and brain exercise.

Generally, there are two types of video games: Hardcore and casual video games (CVGs).

Hardcore video games are harder to play; they are usually played for a long time period.

However, hardcore action video games were mostly used in most research during the past years to study the improvement of perceptual and cognitive abilities in the younger audience.

Furthermore, the interaction between old people and this type of video games could be very difficult.

First, learning how to play an action video game could be very difficult and challenging for the elderly, and secondly, as many authors suggested, the elderly usually dislike action video games, especially when they have violent content [46].

To sum up, all these results suggest that the elderly could be less motivated to be involved trough action video game interventions which are less attractive.

On the other side, casual video games (CVGs) have short play session and are an easy task to be played, and this is the reason why they are mainly a target for old people improving cognitive functions and emotional well-being [47].

Different CVG genres engage different perpetual and cognitive functions, and it is important to understand the logical process under these video games to improve specific cognitive abilities [48].

In order to understand better which CVGs are more suitable and enjoyed by the elderly, many authors from Switzerland have studied what older people like to play [49].

In this study, Chesham and coworkers [48] have evaluated 16 healthy older adults (5 females and 11 males) aged between 65- and 84-year olds coping with games.

All the participants have no deficit vision, and exclusion criteria were a diagnosis of dementia, mild cognitive impairment, and motor impairments leading to inability to manage a tablet computer.

Finally, all participants were informed about the procedure of the study and signed for the informed consent.

We examined casual game enjoyment and game characteristics across a range of four genres (casual action, casual puzzle, casual simulation and casual strategy games) based on different cognitive functions in healthy older adults.

The results of this study suggest that tablet-based casual games have been enjoyed by the elderly.

A possible limitation of the study was that all the subjects were healthy and well-motivated to participate in the research.

No prior game experience was considered as possible bias in the obtained results.

5.2 A social virtual reality-based applications: The physical and cognitive training of the elderly

Virtual reality is an interactive and immersive experience that can be used to transport patients to a place beyond the clinical setting.

Patients can experience realistic, three-dimensional worlds that aim to not just reduce the stress and anxiety of a clinic visit but also teach patients' and the clinicians' new skills [50].

Generally, virtual reality is usually used to enhance many cognitive abilities (attention) in clinical disease.

Because virtual reality is an interactive method, it is mostly involved in rehabilitation and education in children [51].

It leads the opportunity to work on creating a new virtual world.

There have been several numbers of software created to deflect the minds of patients and focus more on virtual reality worlds that can help them to relieve stress and to stimulate cognitive functions.

Virtual reality-based cognitive stimulation can also be used to improve cognitive functions in critically ill patients, and most research involved the elderly population [52]*.

This tool could be a valid instrument to prevent the patients from the overload of disturbing extra-stimuli, especially during the hospitalization period.

Furthermore, thanks to virtual reality, it is possible to select natural restorative environments with neutral content.

Generally, there is a distinction between virtual environments (VE) and virtual world (VW).

In virtual environments, people could see characters and objects interacting with them in a realist way in real time.

On the other hand, virtual worlds consist of a social world that is more stable, where people could interact with other users using an artificial avatar [53].

One challenge in using VR stimulation in old people especially in a critical situation is to engage their attention in a suitable and relaxing scenario [54].

Many authors suggested that visual exposure to the natural environment (e.g. landscapes, vegetation and water) has a protective role against stress, restoring physiological, emotional and attention functions [55].

The attention restoration theory suggests that exposure to natural environments combined with sounds has a relaxing effect.

The attention request from the clinical setting is lower, and this promotes a sense of being away, stimulating less cognitive domains.

This has a crucial role in cognitive abilities because it allows the attention capacity to be restored [56].

Chirico et al. focused on the level of immersion given by this experience.

They found out that exposure of VR nature environment stimuli can trigger a parasympathetic activation, inducing strong emotion and a vivid sense of scene [57].

Gerber and colleagues [58] conducted an interesting study in order to investigate how virtual reality could help to relax in the intensive care unit.

In this study, three different nature VR videos (landscape, water worlds and animals) were presented.

To measure the visual exploration behavior (e.g. where the patient "looks at" and whether the eyes are open), the video-oculography was used.

Furthermore, to measure participant's reactions to the virtual reality stimuli, many vital parameters (heart rate, blood pressure, etc.) were recorded while the videos were presented to the patients.

The results suggest that in line with previous studies, the exposure to virtual nature environments produced a relaxing effect.

In fact, all vital sign measurements (heart frequency, respiratory frequency) significantly decreased during the session of virtual reality.

This could show a positive link between VR and the reduction of psychological stress.

In addition, no fatigue in visual exploration task and target stimulus has affected the visual exploration behavior.

Finally, the VR scenario was accepted by all the participants of the study and the possibility to be adapted for use in frailty patients.

6. Future perspective of research and the potential benefit of the use of the proposed model in the clinical setting

The aging population is increasing, making a critical impact on social care.

Therefore, from our point of view, it is necessary to consider new potential solutions as a therapeutic instrument to help frailty people.

A potential benefit solution comes from positive technology.

The aim of this approach is contributing to the development of well-being for the elderly and allows them to maintain their autonomy in their activities of daily living.

It is necessary to consider that positive technology could have a positive effect on the psychological well-being of the elderly in an alternative way from the classical therapeutic intervention which has already been used.

Also, taking together the main geriatrics models and deep comprehension of the cognitive and emotional functions of the older gives the clinicians an opportunity to embrace multiple disciplines.

It is crucial to consider many different aspects of the aging process from a different point of view (medical, psychological and engineering).

This multidisciplinary approach gives the clinicians the opportunity to develop and implement an innovative cognitive rehabilitation program providing to the elderly strategies to increase motivation and social relationship in every clinical setting.

In conclusion, future research should be focused on the importance of technology as an instrument that could be used by the clinicians, the elderly patients and especially their family to reduce the distance between them.

It has to be considered that most of the frailty elderly are in critical conditions and live in nursing homes away from their family.

Positive technology could represent a bridge of hope between them and their families, contributing to keeping alive a sense of community and the joy of sharing their emotions.

7. Conclusion

The basic objective of this book chapter is to briefly describe the complexity of aging, the impact of cognitive representation on emotions and life events, and the role of new technology's solution and physical activity as therapeutic interventions.

These results confirm the importance of considering multidimensional aspects of the aging process (psychological mechanism and physical structures).

Taking together there are really good changes that in the near future will be possible to help many humans to live healthy aging.

Author details

Francesca Romana Greco and Grazia D'Onofrio*
Geriatric Unit, Department of Medical Sciences, IRCCS Casa Sollievo Della Sofferenza, San Giovanni Rotondo, Italy

*Address all correspondence to: g.donofrio@operapadrepio.it

References

[1] Dent E, Kowal P, Hoogendijk EO. Frailty measurement in research and clinical practice: A review. European Journal of Internal Medicine. 2016;**31**: 3-10

[2] Bennett JE et al. The future of life expectancy and life expectancy inequalities in England and Wales: Bayesian spatiotemporal forecasting. Lancet. 2015;**386**:163-170

[3] Ožić S et al. Interventions aimed at loneliness and fall prevention reduce frailty in elderly urban population. Medicine (United States). 2020;**99**

[4] Ge S, Zhu Z, Wu B, McConnell ES. Technology-based cognitive training and rehabilitation interventions for individuals with mild cognitive impairment: A systematic review. BMC Geriatrics. 2018;**18**

[5] Kinsella K, Phillips DR, Butz WP, Bentzen MP, Hokenson RF. Global aging: The challenge of success Population Reference Bureau (PRB). Population Reference Bureau. 2005;**60**:1-44

[6] Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K. Frailty in elderly people. Lancet. 2013;**381**:752-762

[7] Rockwood K et al. A frailty index based on deficit accumulation quantifies mortality risk in humans and in mice. Scientific Reports. 2017;**7**:1-10

[8] Fried LP et al. Frailty in older adults: Evidence for a phenotype. The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences. 2001;**56**: M146-M157

[9] Aubertin-Leheudre M, Woods AJ, Anton S, Cohen R, Pahor M. Frailty clinical phenotype: A physical and cognitive point of view. Nestle Nutrition Institute Workshop Series. 2015;**83**:55-63. DOI: 10.1159/000382061.FRAILTY

[10] Kirkwood TBL. Understanding the odd science of aging. Cell. 2005;**120**: 437-447

[11] Hewitt J et al. Frailty predicts mortality in all emergency surgical admissions regardless of age. An observational study. Age and Ageing. 2019;**48**:388-394

[12] Eeles EMP, White SV, O'mahony SM, Bayer AJ, Hubbard RE. The impact of frailty and delirium on mortality in older inpatients. Age and Ageing. 2012;**41**:412-416

[13] Rivan NFM et al. Incidence and predictors of cognitive frailty among older adults: A community-based longitudinal study. International Journal of Environmental Research and Public Health. 2020;**17**:1-17

[14] Buchman AS, Boyle PA, Wilson RS, Tang Y, Bennett DA. Frailty is associated with incident Alzheimer's disease and cognitive decline in the elderly. Psychosomatic Medicine. 2007; **69**:483-489

[15] Boyle PA, Buchman AS, Wilson RS, Leurgans SE, Bennett DA. Physical frailty is associated with incident mild cognitive impairment in community-based older persons. Journal of the American Geriatrics Society. 2010;**58**:248-255

[16] Sutton JL, Gouldon RL, Coulson MC, Ward EV, Butler AM, Smith M, et al. Multicomponent frailty assessment tools for older people with psychiatric disorder: A systematic review. Journal of the American Geriatrics Society. 2018;**67**:1085-1095

[17] Brazil K et al. Anticipatory care planning intervention for older adults at risk of functional decline: Study protocol for a primary care cluster feasibility randomised trial. Trials. 2020; **21**:1-10

[18] Rockwoo K, Song X, MacKnight C, Bergman H, Hogan DB, McDowell I, et al. A global clinical measure of fitness and frailty in elderly people. Canadian Medical Association Journal. 2005;**173**: 489-495

[19] Op Het Veld LPM et al. Fried phenotype of frailty: Cross-sectional comparison of three frailty stages on various health domains. BMC Geriatrics. 2015;**15**:1-11

[20] Ellis G, Gardner M, Tsiachristas A, Langhorne P, Burke O, Harwood RH, et al. Comprehensive geriatric assessment for older adults admitted to hospital (review). Cochrane Library Database of Systematic Reviews. 12 September 2017;**9**(9). DOI: 10.1002/14651858.CD006211.pub3

[21] Rodger KTM, Greasley-Adams C, Hodge Z, Reynish E. Expert opinion on the management of pain in hospitalised older patients with cognitive impairment: A mixed methods analysis of a national survey. BMC Geriatrics. 2015;**15**:1-5

[22] Mathias S, Nayak US, Isaacs B. Balance in elderly patients: The 'get-up and go' test. Archives of Physical Medicine and Rehabilitation. 1986;**67**: 387-389

[23] Stillman GR, Stillman AN, Beecher MS. Frailty is associated with early hospital readmission in older medical patients. Journal of Applied Gerontology. 2019;**6**:1-9. DOI: 10.1177/0733464819894926

[24] Wilkinson P, Ruane C, Tempest K. Depression in older adults. BMJ. 2018; **363**:363-389

[25] Mayer JD, Caruso DR, Salovey P. The ability model of emotional intelligence: Principles and updates. Emotion Review. 2016;**8**:290-300

[26] Beadle JN, Sheehan AH, Dahlben B, Gutchess AH. Aging, empathy, and prosociality. The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences. 2015;**70**:213-222

[27] Ruffman T, Halberstadt J, Murray J. Recognition of facial, auditory, and bodily emotions in older adults. The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences. 2009;**64**:696-703

[28] Grainger SA, Henry JD, Phillips LH, Vanman EJ, Allen R. Age deficits in facial affect recognition: The influence of dynamic cues. The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences. 2017;**72**: 622-632

[29] Cahill L, Uncapher M, Kilpatrick L, Alkire MT, Turner J. Sex-related hemispheric lateralization of amygdala function in emotionally influenced memory: An fMRI investigation. Learning & Memory. 2004;**11**:261-266

[30] Cornelis E, Gorus E, Van Schelvergem N, De Vriendt P. The relationship between basic, instrumentals, and advanced activities of daily living and executive functioning in geriatric patients with neurocognitive disorders. International Journal of Geriatric Psychiatry. 2019;**34**:889-899

[31] Almeida OP et al. Depression, frailty, and all-cause mortality: A cohort study of men older than 75 years. Journal of the American Medical Directors Association. 2015;**16**:296-300

[32] Armstrong JJ et al. Social vulnerability and survival across levels of frailty in the Honolulu-Asia aging study. Age and Ageing. 2015;**44**:709-712

[33] Tornero-Quiñones I, Sáez-Padilla J, Díaz AE, Robles MTA, Robles ÁS. Functional ability, frailty and risk of falls in the elderly: Relations with autonomy in daily living. International Journal of Environmental Research and Public Health. 2020;**17**:1-12

[34] Isabelle MP, Simon M. Comparison between elderly and young drivers' performances on a driving simulator and self-assessment of their driving attitudes and mastery. Accident; Analysis and Prevention. 2020;**135**: 105317

[35] Baldock MRJ, Mathias JL, McLean AJ, Berndt A. Self-regulation of driving and its relationship to driving ability among older adults. Accident; Analysis and Prevention. 2006;**38**: 1038-1045

[36] Riva G. What is positive technology and it's impact on cyber psychology. Studies in Health Technology and Informatics. 2012;**181**:37-41

[37] Mañas A et al. Which one came first: Movement behavior or frailty? A cross-lagged panel model in the Toledo Study for Healthy Aging. Journal of Cachexia, Sarcopenia and Muscle. April 2020;**11** (2):415-423. DOI: 10.1002/jcsm.12511

[38] Da Silva VD et al. Association between frailty and the combination of physical activity level and sedentary behavior in older adults. BMC Public Health. 2019;**19**:1-6

[39] Riva G et al. Positive technology for healthy living and active ageing. Studies in Health Technology and Informatics. 2014;**203**:44-56

[40] Seligman MEP. Authentic Happiness: Using New Positive Psychology to Realize Your Potential for Lasting Fulfillment. New York: Atria Books; 5 January 2004. pp. 150-336

[41] Graffigna G, Barello S, Wiederhold BK, Bosio AC, Riva G. Positive technology as a driver for health engagement. Annual Review of CyberTherapy and Telemedicine. 2013; **191**:9-17

[42] Keyes CLM, Lopez SJ. Toward a science of mental health: Positive directions in diagnosis and interventions. Handbook of Positive Psychology. Chapter 4. Oxford University Press; 2002. p. 45

[43] Hemberg J, Nyqvist F, Näsman M. 'Homeless in life'—Loneliness experienced as existential suffering by older adults living at home: A caring science perspective. Scandinavian Journal of Caring Sciences. 2018;**33**: 446-456

[44] Arlati S et al. A social virtual reality-based application for the physical and cognitive training of the elderly at home. Sensors (Switzerland). 2019;**19**: 1-17

[45] Doughty K. SPAs (smart phone applications)—A new form of assistive technology. Journal of Assistive Technologies. 2011;**5**:88-94

[46] De Schutter B, Malliet S. The older player of digital games: A classification based on perceived need satisfaction. Communications. 2014;**39**:67-88

[47] Blocker KA, Wright TJ, Boot WR. Gaming preferences of aging generations. Geron. 2014;**12**:174-184

[48] Zelinski EM, Reyes R. Cognitive benefits of computer games for older adults. Geron. 2009;**8**:220-235

[49] Chesham A, Wyss P, Müri RM, Mosimann UP, Nef T. What older people like to play: Genre preferences and acceptance of casual games. JMIR Serious Games. 2017;**5**:e8

[50] Szekley G, Satava RM. Virtual reality in medicine. The BMJ (British Medical Journal). 1999:1-4

[51] Nijhof SL et al. Healthy play, better coping: The importance of play for the development of children in health and disease. Neuroscience and Biobehavioral Reviews. 2018;**95**:421-429

[52] Tuena C, Serino S, Dutriaux L, Riva G, Piolino P. Virtual enactment

effect on memory in young and aged populations: A systematic review. Journal of Clinical Medicine. 2019;**8**:620

[53] Triberti S, Chirico A. Healthy avatars, healthy people: Care engagement through the shared experience of virtual worlds. Transforming Healthcare through Patient Engagement. 2016:247-275. DOI: 10.4018/978-1-5225-0663-8.ch010

[54] Chirico A et al. Effectiveness of immersive videos in inducing awe: An experimental study. Scientific Reports. 2017;**7**:1-11

[55] Valtchanov D, Barton KR, Ellard C. Restorative effects of virtual nature settings. Cyberpsychology, Behavior and Social Networking. 2010;**13**:503-512

[56] Gamble KR, Howard DV. Attention in older adults. Experimental Aging Research. 2016;**40**:1-16

[57] Ulrich RS et al. Stress recovery during exposure to natural and urban environments. Journal of Environmental Psychology. 1991;**11**:201-230

[58] Gerber SM et al. Visuo-acoustic stimulation that helps you to relax: A virtual reality setup for patients in the intensive care unit. Scientific Reports. 2017;**7**