Dance in Virtual Reality for Alzheimer’s Rehabilitation

DAVIMU
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DAVIMU

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1 INTRODUCTION

The Dance in Virtual Reality for Alzheimer Rehabilitation project aims to propose a solution against dependency, isolation and balance issues, which are typical of aged people who suffer from Alzheimer’s disease. For this purpose, the project takes as a premise the use of the perception effect in Alzheimer’s patients, based on their socio-cultural environment as music, with the help of technological tools such as virtual reality. This will result in the creation of DAVIMU which is a tool that is adapted to the user’s motor, cognitive and balance capabilities while dancing, in order to enhance these skills.

A lot of work has been done, based on the interaction between humans and machines for medical purposes, making use of technologies, such as, cameras for motion capture, special lenses for immersive ambiances and haptic technologies for tactile perception, among others, all seeking to improve the user’s motor, balance, social and cognitive skills.

The project was developed through collaborative work between IMAGE lab (Arts & Métiers ParisTech, France), IMAGINE team (Universidad de los Andes, Colombia) and Burgundy University (France).

The research and development of the project will be focused on the interaction between music, dance and virtual reality, and how this can enhance the user’s motor and cognitive capabilities. Our approach is to provide a virtual reality tool, DAVIMU with the purpose of encouraging the patient to dance, while training different cognitive and motor aspects.

Music and Dance are important for human life. They are defined by a social and cultural environment and are linked to the different stages of human life. On the one hand, music has the ability to access affective/motivational systems in the brain, while providing time structures and enhancing perception processes, mainly in the range of cognition, language and motor learning (Galinska, 2015). Dance, on the other hand, provides benefits for human health and social, emotional–affective and cognitive functions (Guzmán et al., 2012).
Nowadays, virtual reality is being used to recreate spaces, where users can interact with the machine in an intimate way. Virtual environments may produce a similar stimulation to the corresponding neural structure just like the real environment does. (Man, 2010). For that reason, the point of this project is to generate an intimate space for the user’s experience, where users feel comfortable and they are transported back in time and space to the 60’s using DAVIMU, and moreover allowing to increase their interest for the tool.

This document has been organized in three main sections. First, an approach to Alzheimer’s disease and related works, referring to them and their use as treatment methods, based on three disciplines: virtual reality, dance and music.

The second section, will focus on the building and development process of DAVIMU, presenting the different aspects considered during the building stage of DAVIMU, including the cultural environment, the medical purpose and the technological development.

Finally, in the third section, conclusions of the project will be presented, through the initial multidisciplinary results and the further evaluation of the project, seeking to establish the feasibility of a future development in this direction.

2 PROBLEM

Alzheimer's disease is a progressive brain disorder that damages and eventually destroys brain cells, leading to memory loss and changes in the thinking process and other brain functions. It usually develops slowly and gradually gets worse as brain function declines and brain cells eventually wither and die (Alzheimer’s association, 2016). Nowadays, this disease is associated with different cognitive symptoms, (memory problems, attention difficulties, concentration, etc.), physical problems (incontinency, loss of strength, motor alterations), and emotional changes (depression, anxiety, etc.) (Reyes Aragon et al., 2012).
Alzheimer’s disease is associated to Biomarkers identifiable in the cerebral spinal fluid (CSF) and brain, which demonstrates that beta amyloid (Aβ) aggregation and deposition increase slowly from cognitive normality in healthy adults to moderate severity in patients that are clinically diagnosed with Alzheimer’s disease. In humans, a slow accumulation of Aβ in the brain precedes cognitive impairment as measured by the brief neuropsychological screening tests that are currently used (Woodruff-Pak et al., 2012).

![Comparison between healthy cells and Alzheimer's cells](image)

*Figure 1: Comparison between healthy cells (down right) and Alzheimer’s cells (up left) (Alzheimer’s association, 2016).*

Alzheimer's disease leads to nerve cell death and tissue loss throughout the brain. Over time, the brain shrinks dramatically, affecting nearly all its functions (Alzheimer’s association, 2016).
Risk of falls in elderly people has been recently associated with Alzheimer’s disease. Older adults with cognitive impairment, particularly AD, lack of proper attention and perception of their own abilities. This may contribute to a lower perception of fear, associated with the decline of balance, loss in gait, and postural instability, further increasing the risk of falls in this population (S.M. Borges et al., 2014).

At present, there are two kinds of treatments for Alzheimer’s disease, the first one is pharmacologic treatment and the second is non-pharmacologic treatment (Reyes et al., 2012).

Non-pharmacologic treatment has three main goals, the first one is to decrease the progression of cognitive damage in order to maintain the patient’s autonomy and independence. The second one is to maintain the patient’s cognitive function and their quality of life for a long time. And the third goal is to decrease and avoid the presence of emotional and behavioral problems (Reyes et al., 2012).

This research is focused on the non-pharmacologic treatments, in order to encourage users to stimulate their motor and cognitive capabilities, by listening to music, dancing
and interacting in a virtual environment, seeking to improve their cognitive and physical functions.

3 RELATED WORK

In recent years, research has involved virtual reality VR, music or dance, as tools for medical rehabilitation. These treatments are focused on different stages of Alzheimer’s disease, related to different symptoms such as: language loss, memory problems, attention and physical health.

Music is used in some treatments that involve listening or dancing, depending on the specific treatment. Music can contribute to an Alzheimer’s rehabilitation treatment in different aspects, for example, through dance, where the social contact and physical fitness can be improved, or thought listening, where self-expression and speech abilities can be stimulated.

Dance is a multitasking activity that involves movement, visualization and listening. It allows to strengthen the body and its flexibility and, at the same time, it enables the creation of social support networks (Earhart, 2009 & Palo-Bengtsson, 1997). Some studies compare results from different kinds of music (Hackney, 2009); each music genre has its own characteristics or features in terms of: rhythm, tonality and orchestration, which can be associated with cultural and social factors.

Additionally, each genre has specific movements and patterns, which requires non-conventional body gestures. The study’s results show benefits regarding balance, motor ability and locomotion. This can vary depending on the genre (e.g. Argentinian tango, waltz or Foxtrot. On the other hand, the study has shown the effects that result from dancing to salsa music, it demonstrates that listening to music may reduce therapeutic doses of some psychotropic medications, improve mood and self-expression, stimulate speech, organization, and mental processes, promote sensory stimulation and motor integration (Abreu et al., 2013); another study shows an improvement in expressive language and in short and long-term memory, as evidenced by the ability to learn and recall the names of the other members of the
group, as well as past life experiences. It was observed that the patients had progressive positive changes in the aforementioned aspects (Brotons et al., 2003).

Another study uses live instrumental and vocal music in the therapy, to enhance physical movement with non-verbal actions. For example, making a surprised face with the eyebrows. The result throughout movement, singing, and rhythm experiences indicated that participants expressed greater amounts of positive effect during therapy (Cevasco, 2010).

Singing is another treatment for people with Alzheimer’s disease, choosing those songs that were popular when the participants were in either their adolescent years or in their early twenties. The therapist, who was also the researcher, sang with group members and played guitar chords as accompaniment. For the election of the song, different factors were considered: musical elements such as melody, rhythm and harmony, the song’s structure (strophic, through-composed), the lyrics and the song’s central themes (patriotic and lullaby), and the cultural contexts (background, events and decade). The treatment helped to encourage conversation among people; the emotional and arousal states of participants had an effect on their ability to concentrate and, therefore, influenced their language ability (Dassa et al., 2014).

Virtual reality is used in treatments to enhance the quality of life in Alzheimer’s disease patients. Some treatments are based on the recreation of real environments, where users are trained to perform navigation tasks and are tested on their navigation ability (i.e. Virtual Tübingen, when patients have to watch a route through a virtual representation of the German city of Tübingen, and complete some tasks about this route (Claessen et al., 2015).

Another tool for Alzheimer’s treatment is Neuro Vr2 which has different scenarios that can be edited by doctors to enhance multiple skills in Alzheimer’s disease treatment. Patients can be monitored by doctors to analyze stress situations and other factors (Satava et al., 1999).
Moreover, AR-REHAB provides a set of exercises developed using AR technologies and is used for post stroke-patient rehabilitation of their hands and arms based on the current status of the patient. This involves virtual reality with the real world. The tool scans the real world and generates markers to determine the position of an object that is tracking in order to generate a new position on a desk (Alamri et al., 2010).

Another study uses virtual reality and dance as a treatment for urinary incontinence in senior women; movements proposed in the application are based on physiotherapy exercises for urinary incontinence. The women need to follow steps in a videogame to perform pelvic floor muscle exercises, while they are dancing (Elliot et al., 2014).

The DAVIMU tool is proposed based on this related work, where the users are encouraged to interact with music through the movement of their body in a virtual scenario, where the users are transported back to the 60’s, through the music and scenario. While the users exercise their body with movements proposed by the system, they also train their cognitive capabilities, listening to music at the same time. DAVIMU’s main characteristic is the adaptation to the user’s motor and cognitive capabilities, which is reflected in the change of the music’s tempo, based on the user’s movements; if the user moves more slowly, the tempo of the music will slow down, in the same way, if the patient moves faster, the tempo of the music will increase.

4 DAVIMU’S PROPOSAL

DAVIMU is based on the medical aspects of Alzheimer’s disease, as well as on the users’ socio-cultural environment and technological issues. These factors will be explained below from its conception to the final result of the tool. Three main topics were considered for the design of DAVIMU. The first one is the socio-cultural environment; second, the medical purposes of DAVIMU and finally, DAVIMU’s development.

4.1 SOCIO-CULTURAL ENVIRONMENT

Socio-cultural environment refers to factors relating to ethnic or sub-cultural backgrounds and associated practices which may influence perception, communication, interpretation, and media use that is defined by the place of birth.
The user’s cultural environment is important because it determines the audiovisual elements that can enhance the experience of the user; elements that can evoke different moments in the user’s life. The evocation of moments is a consequence of the brain’s stimulation, where the existence of multiple human memory systems mediating the autobiographical record (episodic memory; the context in which a piece was heard), knowledge about the world (semantic memory; recognition of a familiar tune) and learned motor skill sequences (procedural memory; playing an instrument) is well established for a range of sensory phenomena. In a neuropsychological sense, the first two memory systems are ‘explicit’, the last one is ‘implicit’ and all of them are forms of ‘long-term’ memory (contrasted with the ‘short term’ rehearsal of information in working memory). (Jacobsen et al., 2015)

Regarding the cultural environment, the user’s place and date of birth was considered for choosing the music and design of the virtual scenario for DAVIMU. For its design, the cultural environments of people who were born in the 40’s were chosen; a population that at present day are around sixty years old. Considering that this is the average age in which Alzheimer’s is detected. When the presence of the Apolipoprotein E (APOE), which is associated to Alzheimer’s disease, is detected in the average age of 50s and 60s, the patients have more rapid memory loss and reduced learning efficiency than matched APOE ε4 no carriers. Clinically healthy APOE ε4 carriers diverge from no carriers before the age of 60 (Caselli et al., 2009).

4.1.1 Target Population
France was selected as the place for the development of the project, including testing and research and, therefore, the target population as well. Patients were not selected from a specific region, leaving the target population open to the whole country. As stated before, the project focused on the average age of appearance of the disease, choosing patients that were born in the 40´s and selecting the 60´s as the cultural environment epoch for the setting –scenario- for the platform, recreating the characteristics of their lives when they were 20 years old. This specific age was selected, since at this age the brain has the ability to memorize more information, and one that can be easily recalled when the person is older. (Rubin et al., 1997).
4.1.2 Music

For music purposes a survey was elaborated, where French citizens within a range of age between 20-25 years old, wrote down the names of supposed favorite singers or bands of their family members over 60 years old. The survey resulted in a list of forty artists and groups from the 60’s, with a diversity of several music genres (Annex 1).

The list was classified by musicians and genre, where artists who played dance music or musique de variétés were chosen. This is a commercial radio format which encompasses several styles. Generally, it is strongly melodic and often features vocal harmony techniques and orchestral arrangements. Popular during the 60’s and the 70’s (Wikipedia, 2016).

Further research was done in order to establish a top five of the audience’s favorite songs for each musician included in the list. The resulting songs were classified and analyzed based on three main criteria that would help to determine different patterns and allow interaction between DAVIMU and the user:

- Rhythm: People recognize the beats in music, and clap or wave their hands according to the rhythm (Shiratori et al. 2015). This is based on the metric; generally it has a main beat that is perceived by people, since it is louder than the other beats. For example, in 4/4 metrics, the first and third beats are perceived louder than the second and fourth beats.

- Music mood: based on harmony, people can determine if music has a sad mood or happy mood (Shiratori et al. 2015). That depends on the tone of the piece; if it is a major scale, the mood should be happy in contrast to a minor scale that is perceived as a sad mood.

  The movement of the user can be directly linked to the music’s mood, and defining how this could be, for example: In a sad song the user moves more slowly and softer; on the other hand, with happy music, the user tends to move stronger and faster.

- Music intensity: depends on the melody’s frequency. When the melody has a higher tone, the perception of the intensity is higher too. This is caused by the
waveform, because high-frequency waves are smaller than low-frequency waves.

Based on these musical characteristics, songs with 4/4 metrics were chosen, being this type of songs easier to understand; it is a common metric in the music repertoire and additionally it is even, which means that movement can also be recognized in pairs. Songs with a constant rhythmic instrumentation were also chosen; these are songs that have bass or drums maintaining a constant rhythm throughout the song.

Songs categorized as ones with a happy mood were chosen, seeking to enhance the user’s movement; encouraging the dance and music experience. Songs with a melodic line of voice, and with melodic patterns that were repeated throughout the song were preferred, since it helped them to understand and memorize the structure of the song, recognizing the chorus and the phrases of it.

Furthermore, another criterion to choose music, was the midi accessible file, where the congruency between the original track with the midi track was evaluated. This means that the timbre of the instruments and the singer in the song was similar.

Finally, the result of this musical analysis was a list of fourteen songs (Table 1).

Table 1: Chosen songs for DAVIMU.

<table>
<thead>
<tr>
<th>Release Year</th>
<th>Song Name</th>
<th>Artist</th>
<th>Link</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977</td>
<td>La Java de Broadway</td>
<td>Sardou Michel</td>
<td><a href="https://www.youtube.com/watch?v=bxqZyvcLx5U">https://www.youtube.com/watch?v=bxqZyvcLx5U</a></td>
<td>4/4</td>
</tr>
<tr>
<td>1977</td>
<td>Dix ans plus tôt</td>
<td>Sardou Michel</td>
<td><a href="https://www.youtube.com/watch?v=5JGOVBRIgArY">https://www.youtube.com/watch?v=5JGOVBRIgArY</a></td>
<td>4/4</td>
</tr>
<tr>
<td>1971</td>
<td>Le rire du sergent</td>
<td>Sardou Michel</td>
<td><a href="https://www.youtube.com/watch?v=Dyz7OSCU">https://www.youtube.com/watch?v=Dyz7OSCU</a></td>
<td>4/4</td>
</tr>
<tr>
<td>Year</td>
<td>Title</td>
<td>Artist</td>
<td>Youtube Link</td>
<td>Length</td>
</tr>
<tr>
<td>------</td>
<td>------------------------------------------</td>
<td>-----------------</td>
<td>-----------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>1973</td>
<td>Les Villes de solitude</td>
<td>Sardou Michel</td>
<td><a href="https://www.youtube.com/watch?v=Y2YTqW-jzl4">https://www.youtube.com/watch?v=Y2YTqW-jzl4</a></td>
<td>4/4</td>
</tr>
<tr>
<td>1961</td>
<td>Il Faut Savoir</td>
<td>Charles Aznavour</td>
<td><a href="https://www.youtube.com/watch?v=OHVVoYuNYEw">https://www.youtube.com/watch?v=OHVVoYuNYEw</a></td>
<td>4/4</td>
</tr>
<tr>
<td>1962</td>
<td>Les comédiens</td>
<td>Charles Aznavour</td>
<td><a href="https://www.youtube.com/watch?v=6KF5a04oANY">https://www.youtube.com/watch?v=6KF5a04oANY</a></td>
<td>4/4</td>
</tr>
<tr>
<td>1964</td>
<td>For me formidable</td>
<td>Charles Aznavour</td>
<td><a href="https://www.youtube.com/watch?v=Oa4kA7MZL4s">https://www.youtube.com/watch?v=Oa4kA7MZL4s</a></td>
<td>2/2</td>
</tr>
<tr>
<td>1966</td>
<td>Ça M'avance À Quoi</td>
<td>Joe Dassin</td>
<td><a href="https://www.youtube.com/watch?v=Alp3G4n19k">https://www.youtube.com/watch?v=Alp3G4n19k</a></td>
<td>4/4</td>
</tr>
<tr>
<td>1969</td>
<td>Le petit pain au chocolat</td>
<td>Joe Dassin</td>
<td><a href="https://www.youtube.com/watch?v=FaswDL7ZU8c">https://www.youtube.com/watch?v=FaswDL7ZU8c</a></td>
<td>4/4</td>
</tr>
<tr>
<td>1970</td>
<td>Cécilia</td>
<td>Joe Dassin</td>
<td><a href="https://www.youtube.com/watch?v=4cn7WDVkQFY">https://www.youtube.com/watch?v=4cn7WDVkQFY</a></td>
<td>4/4</td>
</tr>
<tr>
<td>1970</td>
<td>L'Amérique</td>
<td>Joe Dassin</td>
<td><a href="https://www.youtube.com/watch?v=aowlqthVo8c">https://www.youtube.com/watch?v=aowlqthVo8c</a></td>
<td>4/4</td>
</tr>
<tr>
<td>1965</td>
<td>Bip-bip</td>
<td>Joe Dassin</td>
<td><a href="https://www.youtube.com/watch?v=KirTvEe0tl0">https://www.youtube.com/watch?v=KirTvEe0tl0</a></td>
<td>4/4</td>
</tr>
<tr>
<td>1963</td>
<td>Sans toi ma mie</td>
<td>Salvatore Adamo</td>
<td><a href="https://www.youtube.com/watch?v=xS2cHDko2wM">https://www.youtube.com/watch?v=xS2cHDko2wM</a></td>
<td>4/4</td>
</tr>
<tr>
<td>1964</td>
<td>Vous permettez monsieur</td>
<td>Salvatore Adamo</td>
<td><a href="https://www.youtube.com/watch?v=O70E5PYved4">https://www.youtube.com/watch?v=O70E5PYved4</a></td>
<td>4/4</td>
</tr>
<tr>
<td>1963</td>
<td>Biche oh ma biche</td>
<td>Frank Alamo</td>
<td><a href="https://www.youtube.com/watch?v=IlC1bUEJpAo">https://www.youtube.com/watch?v=IlC1bUEJpAo</a></td>
<td>4/4</td>
</tr>
<tr>
<td>1962</td>
<td>Le locomotion</td>
<td>Sylvie Vartan</td>
<td><a href="https://www.youtube.com/watch?v=a63nO8ne8rk">https://www.youtube.com/watch?v=a63nO8ne8rk</a></td>
<td>4/4</td>
</tr>
<tr>
<td>1963</td>
<td>Il revient</td>
<td>Sylvie Vartan</td>
<td><a href="https://www.youtube.com/watch?v=UPxRdmNDWY">https://www.youtube.com/watch?v=UPxRdmNDWY</a></td>
<td>4/4</td>
</tr>
</tbody>
</table>
1964 | Le tango funèbre | Jacques Brel | https://www.youtube.com/watch?v=zJ6ZTR nzV5M | 4/4 |
1964 | Mathilde | Jacques Brel | https://www.youtube.com/watch?v=wRcxIx ZjJY | 4/4 |
1963 | Pour moi la vie va commencer | Johnny Hallyday | https://www.youtube.com/watch?v=YTJoJR Tb0L8 | 4/4 |
1966 | Noir C’est Noir | Johnny Hallyday | https://www.youtube.com/watch?v=99phIP _e2Rw | 4/4 |
1964 | Ne sois pas si bête | France Gall | https://www.youtube.com/watch?v=_S52gi FOJnA | 4/4 |
1943 | Que Reste-T-il De Nos Amours | Charles Trenet | https://www.youtube.com/watch?v=T_uvg m2_hRk | 4/4 |

### 4.1.3 Scenario Design

In order to be consequent with the idea of transporting the user to a specific time, in this case the 60’s, the design of the scenario was chosen based on the set designs of TV shows’ from the 60’s; particularly those dedicated to TV live concerts, where artists were invited to perform.

Some popular TV concert shows in France during the 60’s are: *Chansons et Champions*, Music Hall France, *Palmarès des Chansons* (Melody, 2016). For the design.

Common characteristics between these three shows were taken in consideration, defining the position of the stage, the font for the titles, the location of the name of the
show, the minimalist style in terms of decoration and inclusion of stairs as a part of the setting.

Figure 3: Visual references 60’s TV shows (Melody, 2016).

Figure 4: DAVIMU scenario design.
4.2 MEDICAL PURPOSES

In the second place, the medical purposes of DAVIMU were considered, this meaning, the definition of the purposes and needs of the medical field, considering what doctors would expect from this kind of tool.

To determine this, a physiotherapist was invited as adviser for the development of DAVIMU; the physiotherapist presented her needs and challenges when attending elderly people. Based on her analysis, she then proposed valuable reference texts regarding elderly people with cognitive deficit.

She offered, as a reference treatment, the proprioceptive neuromuscular facilitation stretching (PNF), where the patient has high levels of participation in the treatment that involves the patient’s social environment and personal background, promoting mobility, muscle strength and balance. Simulating activities of their daily lives (Adler et al., 1993).
The idea of DAVIMU was conceptualized as a choreography for the user, based on a variety of movements proposed by the specialist. For the selection of the movement patterns, she used Balance, Mobility, Resistance and Reach of the patient’s body as evaluation protocols.

The items that she proposed for the movements and the activities are:

- Visual focus to center the patient’s attention in the activity.
- The end of the movements will hold in positions per seconds.
- Encouragement of asymmetric movements, far from the body axis.
- The creation of sensorial reinforcements, like holding body parts in the air, and contact like clapping.
- The creation and repetition of patterns to enhance the user’s short-term memory.

In order to memorize patterns, it is important to associate them with gestures that have a significant affiliate to memories of daily activities, like saying hello and sending a kiss, among others.

*Table 2: Comparison between graphic representation and photos of gestures.*

<table>
<thead>
<tr>
<th>Gesture</th>
<th>Graphic representation</th>
<th>Photo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Say goodbye</td>
<td><img src="image" alt="Graphic representation of Say goodbye gesture" /></td>
<td><img src="image" alt="Photo of Say goodbye gesture" /></td>
</tr>
<tr>
<td>Kiss</td>
<td><img src="image" alt="Graphic representation of Kiss gesture" /></td>
<td><img src="image" alt="Photo of Kiss gesture" /></td>
</tr>
</tbody>
</table>
As a result of the analysis, a choreography with six patterns was proposed. This had the goal to evoke daily-live gestures and, additionally, to reinforce different skills of the user in terms of gait and balance, Annex 2.

4.3 DAVIMU’S SOFTWARE DESIGN

In this section we considered the interaction of DAVIMU with the user, where the user will be motivated to enhance his movement, through music and dance. Additionally, we explain the devices used for the development of DAVIMU and its environments.

The technological development is divided into six main modules, figure 6, each module is branched in entries, goals and expected results that will be explained from a conceptual and technological point of view.
The solution was implemented in Unity, because it is a multiplatform game engine that has the facility to connect with multiple external devices, and for the visual design of DAVIMU.

4.3.1 Music
This module has the music information, it has the ability to read and manage music properties in real time, like instruments’ volume and music tempo (bpm). The module has two entries, the midi file and bpm changes, that is obtained from the elapsed time between user’s movements.

![Diagram of Music Module]

*Figure 7: Music module graphic representation.*

To read music and as a requirement of this project, the *Institut Image* developed a plug-in to read and manage midi file attributes.

The plug-in has the ability to read the instruments, number of channels, volume of each channel and channel, and to play musical information in the midi file. And to manage the volume of each channel, and reproduce music in different tempos (bpm).

A bank of sounds is necessary for this plug-in to work. General Midi protocol is used in this case to maintain the assignation of instruments consigned in the Download Sound DLS. The DLS file format is used to store both, the digital sound data and the
articulation parameters needed to create one or more 'instruments'. An instrument contains 'regions' which point to WAVE 'files' (samples) also embedded in the DLS file. Each region specifies a MIDI note and velocity range which will trigger the corresponding sound and also contains articulation information such as envelopes and loop points. Articulation information can be specified for each individual region or for the entire instrument (MIDI Manufacturers Association, 2016). This module has music with changes of tempo in real time. as an output music with changes of tempo in real time.

4.3.2 Choreography

This module has the movements, postures, and space localization of body parts through time, the result element of these aspects will be called dance step. These dance steps are based on the movements proposed by the expert, explained above in this document.

The output of this module is the order of dance steps and the repetitions of each one of them in the choreography. And the next dance step expected from a point.

Figure 8: Choreography module graphic representation.
4.3.3 Measure
This module is one of the most important in DAVIMU, because, it has the responsibility to measure the user’s response to the audiovisual impulse in time, and to validate the user’s imitation of system proposed movements for user feedback.

![Measure module graphic representation.](image)

The body motion data analysis, is based on Laban Movement Analysis (LMA) that has four stages to compare and evaluate the dance movement of the body: Body, Effort, Shape and Space (Aristidou et al., 2013).

- The body component: describes the structural and physical characteristics of the human body and it is responsible for describing which body parts are moving, connected, and influenced by others, additionally different distances between parts of the body, for example, left and right hand and distance between the root joint and ground, finally gait size (Aristidou et al., 2013).

To reduce the data analysis, the patient's body will be clustered into three groups plus the head. The first group is arms: It includes wrists, elbows, and
hands. Second group: waist, legs, knees, and feet, and the last one is the head. To facilitate the modelling and mapping of the body's position in order to analyze it (Sangeeta et al., 2012).

- The Effort component: describes the intention and the dynamic quality of the movement, the texture, the feeling tone and how the energy is being used in each motion (Aristidou et al., 2013).

This analysis of the dancing process is based on paused frames and moving frames. A paused frame, is the moment when the acceleration of the body is minimum, this position of the body is called “Key-poses”. In contrast to the body transitions where the body has acceleration and it is between the key-poses (Shiratori et al., 2006).

- Shape: This analyses the way the body changes shape during movement; it describes the static shapes that the body takes, the relation of the body to itself, the relation of the body with the environment, the way the body is changing toward some point in space, and the way the torso can change in shape to support movements in the rest of the body (Aristidou et al., 2013).

In this analysis, it is important to have the position of the body in the X, Y, Z axes to determine measures to compare and evaluate the different states of the patient's body, in order to validate the correct position of the patient's body (Sangeeta et al., 2012).

- Space: describes the movement in relation with the environment, pathways, and lines of spatial tension. Laban classified the principles for the movement orientation based on the body kinesphere (the space within reach of the body, mover’s own personal sphere) and body dynamosphere (the space where the body’s actions take place, the general space which is an important part of personal style) (Aristidou et al., 2013).
Moreover, some parameters were established to organize the body by dependences and spatial relations between body parts in each movement of the dance steps. The user has to validate this postures in terms of space, shape, effort and body components, to advance in the choreography.

The user’s elapsed time between movements will be computed to analyze the user’s movement ability to interact with the system. To perform the analysis, the original bpm of the song was taken as a reference; this value allows DAVIMU to know the expected time until the next dance step.

The expected time \( t_e \) is computed with the real time \( t_r \) of the user’s movement during two bars in real time, where the bar is the way to group beats in music; in the case of 4/4 metric, there are four beats per bar.

\[
\% \text{error bpm} = \frac{\sum (t_e - t_r)}{t_e} \times 100
\]

If the percentage is less than 30% the bpm will maintain the same value, if it is more than 30% the bpm will change in the same proportion of the \% error bpm. The bpm could be reduced or increased; each time this value changes, it will be assigned as the new bpm for the following calculations.

4.3.4 Reader
This module has the responsibility to read the user’s information in real time. The movement of each body part is captured and transformed into X, Y, Z, values for system calculation and functionality.
Kinect Xbox One\(^1\) was used in the first version of DAVIMU to capture the user’s movement because it has the ability to recognize and track 26 joints of the human body in real time.

The information is sent through the IIVR plug-in developed by *Institut Image*, this plug-in manages VRPN\(^2\) devices with open server. Additionally, the plug-in computes the view in systems like Cave\(^3\) through different matrixes to emulate virtual reality.

Furthermore, IIVR, controls the rendering position and resolution width, and supports multi-processing striding of several programs in a parallel process.

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Figure 11: Joints division Kinect. (Jana, 2012).

In order to have more precision in movement tracking, the capture method was changed for one with six cameras OptiTrack Flex 3\(^4\) with Motive Tracker\(^5\) as the capture software. The plug-in used to communicate Unity and Motive is IIVR by VRPN.

The division of body parts was based on the division of Kinect body joints (Jana, 2012). Where the body is divided into 26 joints; this division was chosen for the similarity with Davinci’s division of the human body, and also the similarity with human body articulations.

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\(^4\) [https://www.optitrack.com/products/flex-3/](https://www.optitrack.com/products/flex-3/)

As markers for tracking movement we used nine tracking markers in body parts that were needed to read the movements. The body parts that were used for DAVIMU are: head, wrists, elbows, feet and shoulders.
4.3.5 **Visual**

This module provides the visual help and feedback of DAVIMU. It has two kinds of graphic guides to enhance user movement. The first one are circles on the floor to guide the movement; the blue circles are for the right foot and the red circles are for the left foot. The idea is that the user has to place the corresponding foot in the circles that appear.

![Visual module graphic representation.](image1)

*Figure 15: Visual module graphic representation.*
The choice of the color is related to the socio-cultural semiotic, where the color blue is associated to the right side of the body and the color red to the left side.

![Figure 16: Visual DAVIMU stimulus circles.](image)

The second visual stimulus is a drawn representation of the human body, where DAVIMU shows the user the expected movement through such drawings.

![Figure 17: DAVIMU’s Drawn representation of the expected movement (left), and actual expected movement (right).](image)

### 4.3.6 Feedback

This module communicates to the user the evaluation of his performance in real time; whether the movement is correct or incorrect, or if it is in the correct *tempo* in relation
with music bpm, DAVIMU reacts to encourage the user to improve their performance so that the user will not lose interest.

![Feedback Module Graphic Representation](image)

Figure 18: Feedback module graphic representation.

Currently, DAVIMU has three kinds of feedback. First, bpm changes in real time, depending on the user’s movement skills.

![Visual DAVIMU Feedback Circles](image)

Figure 19: Visual DAVIMU feedback circles.

The second one are green circles when the foot is placed in the right circle and third, lights in the scenario; green if the movement is correct and red if the movement is incorrect.
Additionally, feedback is linked to the evaluation process; music and choreography will be chosen based on these results according to the skills of the user.

5 USER TEST

In order to validate the effectiveness of DAVIMU, a user test was designed, for a population over 60 years old with no preferences of genre, where the user has a complete evaluation of his balance skills, based on the medical support where the physiotherapist expects evolution or progress in the user’s balance and gait with the frequent use of DAVIMU.

In addition to that, it evaluates the user’s trust in DAVIMU, in terms of cultural environment and repeated use of it, in a minimum of six sessions, where the user has to take the proposed test in each session in order to measure their progress.

The designed user test has five stages. First, a health survey SF36, where the goal is to perform an overall health assessment of the possible user. The SF36 evaluates the
user in eight different areas. First, limitations in physical activities due to health issues. Second, limitations in social activities due to physical or emotional issues. Third, limitations in usual role activities because of physical health issues. Fourth, Bodily pain. Fifth, general mental health (psychological distress and well-being). Sixth, limitations in usual role activities because of emotional issues; Seventh, vitality (energy and fatigue). Finally, general health perceptions (Ware, 1992). The MOS 36-item short-form health survey (SF-36). Conceptual framework and item selection (Annex 7).

Second stage is the timed up and go (TUG), this test helps to assess the user’s mobility, and it can determine the mobility of the user and whether they need gait aid (Annex 4).

The third stage is the Berg Balance Scale. This test reflects the user’s balance ability; this test can prevent falls in elderly people by measuring their balance abilities (Berg et al., 1992) (Annex 5).

The fourth stage of the user test is the interaction with DAVIMU. In this stage, the user has to interact in the two modalities of DAVIMU training. The two modalities are: First, the users have to place their feet in the circles on the floor, following a sequence of movements between their feet. Second, users have to follow gesture movements of the avatar with the choreography proposed in Annex 2.

In the last stage, the user has to evaluate the response of DAVIMU in a survey, where the user evaluates subjective factors of it, like music, scenario etc. (Annex 6). The survey is made by parameters of Likert scale. That is a technique to measure attitudes, offering five answer possibilities from extremely disagree to extremely agree, and a neutral opinion in between. A numerical value will be assigned to each answer to measure the survey’s results (Likert, 1932).

As a preliminary user test to adjust DAVIMU’s functionality and evaluate the comfortability of the user with it, a sample group was chosen made up by 10 people without preference of genre, from 25 to 50 years old.
Here, the people have to fulfill the user test as DAVIMU’s target group, in order to identify possible failures in DAVIMU, and to review communication tools used by DAVIMU for interacting with the user. All participants volunteered to take part in the test and they were not paid for this.

6 RESULTS

In this section, first, we describe the intention of the preliminary user test. Second, we describe the characteristics of the general population in the preliminary test. Third, the results in the Berg Balance scale. Fourth, the user’s experience with DAVIMU. Finally, we describe the survey to measure DAVIMU’s feasibility and its results.

With DAVIMU’s preliminary user test, the intention was to measure DAVIMU’s subjective elements that may influence the user’s experience, and their desire to continue using DAVIMU. That is important because it is a tool that will be used as a method of therapy countless times.

Ten people without genre or nationality preference from 25 to 50 years old, with high education level, took a previous test based on the main user test designed, with the purpose of measuring the users’ general perception of the DAVIMU experience, based on socio-cultural aspects and the system’s technological response.

The test consists of three stages. First, a preliminary evaluation of the balance abilities using Berg Balance scale (Annex 5). Second, Interaction with DAVIMU in the two modalities, feet and upper body. And third, survey about DAVIMU’s subjective aspects (Annex 6). A description of the demographic characteristics is provided in Table 3.

Table 3: Participants’ demographic information

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The results of Berg Balance scale for this participants’ group are irrelevant in this target group because in this age’s range balance problems are not common. Just one participant alerted about possible balance problems associated to vertigo disease, but the test result was within average, with no evidence of balance complications.

![User's images Balance Berg Scale test](image)

*Figure 21: User's images Balance Berg Scale test*

The user test is intended to affirm the user’s general comfort when using DAVIMU. In order to verify this hypothesis, some questions about subjective perception of DAVIMU’s visual and musical design were asked, and this was based on the model of evaluation that was used in the Lunar Surface Navigation System, where the authors wanted to measure the application in different categories like motivation, suitability, usability, comprehension and media capability (Asai *et al.*, 2010). In the case of DAVIMU, the idea was to evaluate, music, visual stimulus, feedback, scenario and system response, based on the user’s subjective opinion.

The feasibility of DAVIMU was found to be high in the preliminary user test. The ten participants understood and learned how to interact with DAVIMU in a single session. DAVIMU was considered entertaining and interesting as a therapy.

In each session, participants had to interact with DAVIMU in its two modalities, feet training and body training. The order of the activities was changed between
participants, the first user began his training with the feet activity, while the second participant began with the body training.

In the feet training, a user from China, had a different way to interact with the system, the average of the participants were standing on the circles, waiting for the next DAVIMU’s stimulus, but he was behind the tool’s stimulus waiting for the consequent orders.
To validate the users’ subjective opinions about DAVIMU, for each response in the designed survey (Annex 6), we assigned a numerical value, where five is equivalent to strong approval and one to strong disapproval (Table 4). To measure the user’s general perception, all the scores in each question were averaged in order to know the overall impression of the participants.
Table 4: Survey’s equivalent scores.

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As a result, 46% of the participants in the preliminary user test felt comfortable and approved the functionality of DAVIMU. In total, 60% of the participants had a good or very good opinion and experience with the tool (Figure 25).

In general, participants feel comfortable with music; 85% approved DAVIMU’s music (Figure 26). People who were born in France had listened to the proposed music before
the activity. Participants in general think the music is according to the activity, and would recommend others to follow the training. Music is important in this kind of dance applications like DAVIMU because, for the users, it is very important that the songs are popular, since it increases the interest in the activity (Hoysiniemi, 2006).

![DAVIMU's music perception](image)

**Figure 26: DAVIMU's music perception.**

As for the correlation between the two activities, 60% of the people prefer the legs because of the incorrect response of the system with tall people; the motion capture did not work correctly with people over the average height (1.60m). Additionally, the stimulus of movement was clearly understood with the circles. People have an intuitive interaction with this kind of visualization. Moreover, participants are familiar to this kind of dance step as a result of the socio–cultural experience with video games like *dance dance revolution*[^6] and social dance.

Additionally, DAVIMU was evaluated by the expert (a physiotherapist) who designed the choreography and DAVIMU’s bank of movements. She thinks that the tool has the parameters that she would need when designing a physiotherapy, because the patient can train his laterality and his upper body. With DAVIMU, users are motivated to participate in several therapy sessions because the music and choreography in the system can be changed any time, according to the users’ and therapy needs.

7 CONCLUSION AND FUTURE WORK

DAVIMU is a training tool for people over 60, where the users train their cognitive skills, balance, gait, etc. while dancing. DAVIMU adapts music tempo to the users’ movement and cognitive capabilities.

DAVIMU has three training modes. The first two are, choreographies proposed by the system based on physiotherapy movements. In the first one, the users train their upper body parts and in the second one they train their legs. In the third mode, the trainer can organize a bank of dance steps in the order and with the number of repetitions that they want for the patient’s activity.

The contributions of DAVIMU are multidisciplinary as well as its conception and design. Nowadays, there is not a tool like DAVIMU, with which the physiotherapist can design a new therapy in real time according to the user’s needs, where the patient can
reinforce his balance, laterality, gait and cognitive capabilities simultaneously and the system adapts to the user’s current capabilities in real time.

Moreover, the use of socio-cultural environment with the music and scenario design, in order to reinforce user’s immersion and as main axis in the conception and design of a medical tool like DAVIMU where the users reinforce their cognitive capabilities, their confidence, which can contribute to the development of their social and speech skills (Gammon, 2009 & Fukui et al., 2012).

Furthermore, the adaptation of music to the user’s capabilities in real time; if the user does not have the capability of movement, music will be reduced to a level suitable for the user’s capability. Finally, the use of motion capture, dance and music for medical purposes as therapy for Alzheimer’s disease.

To improve DAVIMU, it is important the communication between user and tool in the different channels i.e. Visual. The graphic elements that are used to stimulate the user’s movement have an important role in DAVIMU, because the clarity and the facility to understand the graphic instruction will be reflected in the user’s interaction (movement). For that reason, it is necessary to have a realistic design of the human body as a guide, where the user can use the model as a real guide of the movement to be performed. Additionally, a visual guide that shows the user’s body position in real time, in order to generate confidence, consistence and to give feedback for user’s movements.

The addition of more dance steps will be considered for future work to train the rest of the user’s body, to train different health aspects. Additionally, the measure and functionality of the user’s gravity center in real time in order to determine additional diseases related to the body i.e. pelvic asymmetry.

Furthermore, the addition of more scenarios to the activity, in order to minimize the user’s repetition sensation throughout the exercise.
The research and addition of different socio-cultural environments in order to make DAVIMU an international application.

The future work on DAVIMU is directly proportional to the physiotherapist’s needs. Our main goal is to generate a complete tool, where the physiotherapist may reinforce many aspects of body functionality with DAVIMU.

8 ACKNOWLEDGMENTS

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Finally, to Institut Image and its people, for the help, infrastructure and funds to make this project possible.

9 BIBLIOGRAPHY


36 - Issue 2 - p 100–108.


[20] Linkert, Rensis. “A technique for the measurement of attitudes”. Archives of Spycology. 1932; Volume 22;


10 ANNEXES

10.1 Annex 1

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<td>Bourvil</td>
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<td>Fernandel</td>
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<td>Marcel Amont</td>
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<td>Rita Mitsouko</td>
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<td>Téléphone</td>
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<td>Gainsbourg</td>
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<td>Jaques brel</td>
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<td>Georges Brassens</td>
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<td>Nana Mouskouri</td>
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<td>Henri Salvador</td>
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<td>Alain Souchon</td>
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<tr>
<td>Laurent Voulzy</td>
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10.2 Annex 2

Choreography no. 1

Song: *Les comédiens*

Video choreography link: https://drive.google.com/file/d/0B8Oc9C-3Qul4Q05pWHhaQkJCX00/view?usp=sharing

Song Link: https://www.youtube.com/watch?v=A7G8mev1t3E

The dance steps are based on daily life and cultural gestures, Every Step dance will be repeated 10 times according to the form of the song.

**The wave**: Is an opening movement, prepares the user for the activity.
**Cover the face:** This movement will work with movements of the girdle and dissociation.

It will help with eye-muscles work, the user will lose focus on the screen, which help the patient to concentrate on the activity.
**Kisses:** the hand goes from the middle line to the upper part in a diagonal movement, which is a movement of the *facilitacion neuromuscular propioceptiva*. The name is F1.
**Brush:** Asymmetric movements in the middle line.

**Hugs:** to strengthen the activity of the low body parts, legs and feet coordination. The goal is for the patients to focus on their feet moving side to side.
10.3 Annex 3
RESEARCH INFORMATION
RESEARCH TITLE: Dance in Virtual Reality for Alzheimer´s Rehabilitation

INTRODUCTION
You are invited to participate voluntarily in this study for a maximum duration of one (1) hour. During this period, you will need to take part in five (5) body-balance test of different complexity.

PURPOSE OF THE STUDY
A new stimulation environment based on music and dance for elderly people. Where the following components will be evaluated:

- Movement guided by audiovisual stimulation.
- Following movements synchronized with music.
- Music Tempo depending on the user’s movement capabilities.
- User progress in terms of balance with the use of the app.

QUALIFICATION TO PARTICIPATE
Requirements of participation in this study:

- Written consent.
- Healthy individual over 60 years.

Participants who cannot take part in this study:

- Individuals with a physical disability.
- Individuals with injures or fractures.
- Individuals who have had recent medical procedures, like surgery.
- Individuals who are experiencing chronic mental stress or adverse physiological states.

STUDY PROCEDURE
**Step 1: Briefing, Consent and screening (10 minutes)**
Participants will be informed about the purpose of the study and their involvement during the experiment. Including the risk, and effects that might occur. Personal information and video of the test will be recorded, the consent form will be signed once the participant has agreed to take part of the study.

**Step 2: Health Questionnaire SF-36 (10 min)**
Participants will fill in the health form in order to determine their eligibility for the study. The result induces the user's overall health conditions.

**Step 3: The Timed Up and Go (TUG) Test (3 minutes)**
Participants will take the test to assess the mobility of the user. And whether they are in risk of falling.

**Step 4: Berg Balance Scale (15-20 minutes)**
Participants will take the test to determine their balance capabilities.

**Step 5: Experiment, DAVIMU test (10 minutes)**
Participants will put on the markers for body recognition by the system. They will use the tool in two modalities. First, use of the upper body, arms and shoulders, and second, use of legs.

**Step 6: Survey of DAVIMU impact (10 minutes)**
Participants will fill in the form where they will evaluate the impact of the tool for them.

**RISKS**
The experiment protocol and equipment used in this experiment are safe and non-invasive. However, possible discomfort during the study may take place. The use of DAVIMU requires constant physical movement, for that reason you can feel tired during the session, depending on the individual. Thus, kindly report to the researcher immediately if you feel any kind discomfort during the study. Upon agreement between the user and the researcher, the study will be ended.
REPORT HEALTH EXPERIENCES
You are responsible for notifying the research staff of any negative experience or discomfort during the study.

PARTICIPATION IN THE STUDY
Your participation in the study is voluntary, you can choose to stop at any time.

POSSIBLE BENEFITS
The results in this study will be used for academic and research purposes, it may be publicly disclosed. However, the identity of the subject will be kept confidential.

CONFIDENTIALITY
Your identity will be kept confidential and will not be made public, unless disclosure is required by law.
Data and video obtained from this study could be published for academic and research purposes.
By signing this consent form, you authorize video and review record information and data transfer described above.

SIGNATURES
By signing this document, I am agreeing to participate in the experiment and to be filmed as part of the research material for possible future publications.
Additionally, I desist of the legal and professional liability of the research team, sponsors or institutions who made part of the project.
The user is free to resign from the experiment when he considers necessary.

User:
Name: ________________
Date: _____________
Signature: ________________
Researchers:
Name: __________________
Date: _________
Signature: __________________

CONTACTS

- **Paola Rojas.** Internship. Institut Image de Chalon-sur-Saône, 2 Rue Thomas Dumorey, 71100, Chalon-sur-Saône rc. giselt10@uniandes.edu.co
- **Frédéric Mérienne,** Director of Institut Image de Chalon-sur-Saône, 2 Rue Thomas Dumorey, 71100, Chalon-sur-Saône frederic.merienne@ensam.eu
- **Jose Tiberio Hernandez,** Associate teacher. Universidad de los Andes. Bogotá, Colombia. jhernand@uniandes.edu.co
10.4 Annex 4

Timed Up and Go (TUG) Test

Name:___________________________  MR: ______________________
Date:________

1. Equipment: arm chair, tape measure, tape, stop watch.

2. Begin the test with the subject sitting correctly (hips all of the way to the back of the seat) in a chair with arm rests. The chair should be stable and positioned such that it will not move when the subject moves from sit to stand. The subject is allowed to use the arm rests during the sit – stand and stand – sit movements.

3. Place a piece of tape or other marker on the floor 3 meters away from the chair so that it is easily seen by the subject.

4. Instructions: “On the word GO you will stand up, walk to the line on the floor, turn around and walk back to the chair and sit down. Walk at your regular pace.

5. Start timing on the word “GO” and stop timing when the subject is seated again correctly in the chair with their back resting on the back of the chair.

6. The subject wears their regular footwear, may use any gait aid that they normally use during ambulation, but may not be assisted by another person. There is no time limit. They may stop and rest (but not sit down) if they need to.

7. Normal healthy elderly usually complete the task in ten seconds or less. Very frail or weak elderly with poor mobility may take 2 minutes or more.

8. The subject should be given a practice trial that is not timed before testing.

9. Results correlate with gait speed, balance, functional level, the ability to go out, and can follow change over time.

Normative Reference Values by Age

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Time in Seconds (95% Confidence Interval)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 – 69 years</td>
<td>8.1</td>
</tr>
</tbody>
</table>
70 – 79 years  9.2  (8.2 – 10.2)
80 – 99 years  11.3  (10.0 – 12.7)

### Cut-off Values Predictive of Falls by Group

<table>
<thead>
<tr>
<th>Group</th>
<th>Time in Seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community Dwelling Frail Older Adults</td>
<td>&gt; 14 associated with high fall risk</td>
</tr>
<tr>
<td>Post-op hip fracture patients at time of 2 discharge³</td>
<td>&gt; 24 predictive of falls within 6 months after hip fracture</td>
</tr>
<tr>
<td>Frail older adults</td>
<td>≥ 30  predictive of requiring assistive device for ambulation and being dependent in ADLs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Date</th>
<th>Time</th>
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References


Additional References


10.5 Annex 5

**Berg Balance Scale**

The Berg Balance Scale (BBS) was developed to measure balance among older people with impairment in balance function by assessing the performance of functional tasks. It is a valid instrument used for evaluation of the effectiveness of interventions and for quantitative descriptions of function in clinical practice and research. The BBS has been evaluated in several reliability studies. A recent study of the BBS, which was completed in Finland, indicates that a change of eight (8) BBS points is required to reveal a genuine change in function between two assessments among older people who are dependent in ADL and living in residential care facilities.

**Description:**
14-item scale designed to measure balance of the older adult in a clinical setting.

**Equipment needed:** Ruler, two standard chairs (one with arm rests, one without), footstool or step, stopwatch or wristwatch, 15 ft walkway

**Completion:**

**Time:** 15-20 minutes

**Scoring:** A five-point scale, ranging from 0-4. “0” indicates the lowest level of function and “4” the highest level of function. Total Score = 56

**Interpretation:** 41-56 = low fall risk

21-40 = medium fall risk

0 –20 = high fall risk

A change of 8 points is required to reveal a genuine change in function between 2 assessments.
# Berg Balance Scale

Name: _____________________________  Date: ________________

Location: __________________________ Rater: ________________

<table>
<thead>
<tr>
<th>ITEM DESCRIPTION</th>
<th>SCORE (0-4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting to standing</td>
<td></td>
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<tr>
<td>Standing unsupported</td>
<td></td>
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<tr>
<td>Sitting unsupported</td>
<td></td>
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<tr>
<td>Standing to sitting</td>
<td></td>
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<tr>
<td>Transfers</td>
<td></td>
</tr>
<tr>
<td>Standing with eyes closed</td>
<td></td>
</tr>
<tr>
<td>Standing with feet together</td>
<td></td>
</tr>
<tr>
<td>Reaching forward with outstretched arm</td>
<td></td>
</tr>
<tr>
<td>Retrieving object from floor</td>
<td></td>
</tr>
<tr>
<td>Turning to look behind</td>
<td></td>
</tr>
<tr>
<td>Turning 360 degrees</td>
<td></td>
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<tr>
<td>Placing alternate foot on stool</td>
<td></td>
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<tr>
<td>Standing with one foot in front</td>
<td></td>
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<tr>
<td>Standing on one foot</td>
<td></td>
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<tr>
<td>Total</td>
<td></td>
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</table>

## GENERAL INSTRUCTIONS

Please document each task and/or give instructions as written. When scoring, please **record the lowest response category that applies** for each item.

In most items, the subject is asked to maintain a given position for a specific time. Progressively more points are deducted if:

- the time or distance requirements are not met
- the subject’s performance warrants supervision
- the subject touches an external support or receives assistance from the examiner

Subject should understand that they must maintain their balance while attempting the tasks. The choices of which leg to stand on or how far to reach are left to the subject. Poor judgment will adversely influence the performance and the scoring.

Equipment required for testing is a stopwatch or watch with a second hand, and a ruler or other indicator of 2, 5, and 10 inches. Chairs used during testing should be a reasonable height. Either a step or a stool of average step height may be used for item # 12.
Berg Balance Scale

SITTING TO STANDING
INSTRUCTIONS: Please stand up. Try not to use your hand for support.
( ) 4 able to stand without using hands and stabilize independently
( ) 3 able to stand independently using hands
( ) 2 able to stand using hands after several tries
( ) 1 needs minimal aid to stand or stabilize
( ) 0 needs moderate or maximal assist to stand

STANDING UNSUPPORTED
INSTRUCTIONS: Please stand for two minutes without holding on.
( ) 4 able to stand safely for 2 minutes
( ) 3 able to stand 2 minutes with supervision
( ) 2 able to stand 30 seconds unsupported
( ) 1 needs several tries to stand 30 seconds unsupported
( ) 0 unable to stand 30 seconds unsupported

If a subject is able to stand 2 minutes unsupported, score full points for sitting unsupported. Proceed to item #4.

SITTING WITH BACK UNSUPPORTED BUT FEET SUPPORTED ON FLOOR OR ON A STOOL
INSTRUCTIONS: Please sit with arms folded for 2 minutes.
( ) 4 able to sit safely and securely for 2 minutes
( ) 3 able to sit 2 minutes under supervision
( ) 2 able to sit 30 seconds
( ) 1 able to sit 10 seconds
( ) 0 unable to sit without support 10 seconds

STANDING TO SITTING
INSTRUCTIONS: Please sit down.
( ) 4 sits safely with minimal use of hands
( ) 3 controls descent by using hands
( ) 2 uses back of legs against chair to control descent
( ) 1 sits independently but has uncontrolled descent
( ) 0 needs assist to sit

TRANSFERS
INSTRUCTIONS: Arrange chair(s) for pivot transfer. Ask subject to transfer one way toward a seat with armrests and one way toward a seat without armrests. You may use two chairs (one with and one without armrests) or a bed and a chair.
( ) 4 able to transfer safely with minor use of hands
( ) 3 able to transfer safely definite need of hands
( ) 2 able to transfer with verbal cuing and/or supervision
( ) 1 needs one person to assist
( ) 0 needs two people to assist or supervise to be safe

STANDING UNSUPPORTED WITH EYES CLOSED
INSTRUCTIONS: Please close your eyes and stand still for 10 seconds.
( ) 4 able to stand 10 seconds safely
( ) 3 able to stand 10 seconds with supervision
( ) 2 able to stand 3 seconds
( ) 1 unable to keep eyes closed 3 seconds but stays safely
( ) 0 needs help to keep from falling

STANDING UNSUPPORTED WITH FEET TOGETHER
INSTRUCTIONS: Place your feet together and stand without holding on.
( ) 4 able to place feet together independently and stand 1 minute safely
( ) 3 able to place feet together independently and stand 1 minute with supervision
( ) 2 able to place feet together independently but unable to hold for 30 seconds
( ) 1 needs help to attain position but able to stand 15 seconds feet together
( ) 0 needs help to attain position and unable to hold for 15 seconds

REACHING FORWARD WITH OUTSTRETCHED ARM WHILE STANDING
INSTRUCTIONS: Lift arm to 90 degrees. Stretch out your fingers and reach forward as far as you can. (Examiner places a ruler at the end of fingertips when arm is at 90 degrees. Fingers should not touch the ruler while reaching forward. The recorded measure is the distance forward that the fingers reach while the subject is in the most forward lean position. When possible, ask subject to use both arms when reaching to avoid rotation of the trunk.)
( ) 4 can reach forward confidently 25 cm (10 inches)
( ) 3 can reach forward 12 cm (5 inches)
( ) 2 can reach forward 5 cm (2 inches)
( ) 1 reaches forward but needs supervision
( ) 0 loses balance while trying/requires external support

PICK UP OBJECT FROM THE FLOOR FROM A STANDING POSITION
INSTRUCTIONS: Pick up the shoe/slipper, which is in front of your feet.
( ) 4 able to pick up slipper safely and easily
( ) 3 able to pick up slipper but needs supervision
( ) 2 unable to pick up but reaches 2-5 cm (1-2 inches) from slipper and keeps balance independently
( ) 1 unable to pick up and needs supervision while trying

63
( ) 0  unable to try/needs assist to keep from losing balance or falling

TURNING TO LOOK BEHIND OVER LEFT AND RIGHT SHOULDERS WHILE STANDING

INSTRUCTIONS: Turn to look directly behind you over toward the left shoulder. Repeat to the right. (Examiner may pick an object to look at directly behind the subject to encourage a better twist turn.)

( ) 4  looks behind from both sides and weight shifts well
( ) 3  looks behind one side only other side shows less weight shift
( ) 2  turns sideways only but maintains balance
( ) 1  needs supervision when turning
( ) 0  needs assist to keep from losing balance or falling

TURN 360 DEGREES

INSTRUCTIONS: Turn completely around in a full circle. Pause. Then turn a full circle in the other direction.

( ) 4  able to turn 360 degrees safely in 4 seconds or less
( ) 3  able to turn 360 degrees safely one side only 4 seconds or less
( ) 2  able to turn 360 degrees safely but slowly
( ) 1  needs close supervision or verbal cuing
( ) 0  needs assistance while turning

PLACE ALTERNATE FOOT ON STEP OR STOOL WHILE STANDING UNSUPPORTED

INSTRUCTIONS: Place each foot alternately on the step/stool. Continue until each foot has touched the step/stool four times.

( ) 4  able to stand independently and safely and complete 8 steps in 20 seconds
( ) 3  able to stand independently and complete 8 steps in > 20 seconds
( ) 2  able to complete 4 steps without aid with supervision
( ) 1  able to complete > 2 steps needs minimal assist
( ) 0  needs assistance to keep from falling/unable to try

STANDING UNSUPPORTED ONE FOOT IN FRONT

INSTRUCTIONS: (DEMONSTRATE TO SUBJECT) Place one foot directly in front of the other. If you feel that you cannot place your foot directly in front, try to step far enough ahead that the heel of your forward foot is ahead of the toes of the other foot. (To score 3 points, the length of the step should exceed the length of the other foot and the width of the stance should approximate the subject’s normal stride width.)

( ) 4  able to place foot tandem independently and hold 30 seconds
( ) 3  able to place foot ahead independently and hold 30 seconds
( ) 2  able to take small step independently and hold 30 seconds
( ) 1  needs help to step but can hold 15 seconds
( ) 0  loses balance while stepping or standing

STANDING ON ONE LEG

INSTRUCTIONS: Stand on one leg as long as you can without holding on.

64
(  ) 4  able to lift leg independently and hold > 10 seconds
(  ) 3  able to lift leg independently and hold 5-10 seconds
(  ) 2  able to lift leg independently and hold ≥ 3 seconds
(  ) 1  tries to lift leg unable to hold 3 seconds but remains standing independently.
(  ) 0  unable to try of needs assist to prevent fall

(  ) TOTAL SCORE (Maximum = 56)
10.6 Annex 6

Survey to measure the impact of DAVIMU Tool

Name: _______________________     Id: __________Date: _____________ Nationality: __________ Age: __________

First Song: _______________________

This survey wants to measure your experience with the DAMIVU tool. Please answer the following questions:

1. **How do you feel about the activity?**
   
   a) I feel very comfortable  
   b) I feel comfortable  
   c) I don't feel comfortable or uncomfortable  
   d) I feel uncomfortable  
   e) I feel too uncomfortable

2. **How do you feel about the response of the system? First Song.**
   
   a) I feel very comfortable  
   b) I feel comfortable  
   c) I don't feel comfortable or uncomfortable  
   d) I feel uncomfortable  
   e) I feel too uncomfortable

3. **How do you feel about the response of the system? Second song.**
   
   a) I feel very comfortable  
   b) I feel comfortable  
   c) I don’t feel comfortable or uncomfortable  
   d) I feel uncomfortable  
   e) I feel too uncomfortable

4. **Please which is your punctuation for the music.**
   
   a) very good  
   b) good  
   c) more or less  
   d) bad  
   e) very bad

5. **Have you ever listened to the music in the activity?**
   
   a) Yes  
   b) No

6. **If you have, when and where?**

   ______________________

7. **Do you feel comfortable with the music?**
   
   a) I feel very comfortable  
   b) I feel comfortable  
   c) I don't feel comfortable or uncomfortable  
   d) I feel uncomfortable  
   e) I feel too uncomfortable

8. **How do you feel about movement instructions? First Song.**
   
   a) very good  
   b) good  
   c) more or less  
   d) bad  
   e) very bad

9. **How do you feel about movement instructions? Second song.**
   
   a) very good  
   b) good  
   c) more or less  
   d) bad  
   e) very bad

10. **Are the movement instructions clear? First Song.**
    
    a) Yes  
    b) No

11. **Are the movement instructions clear? Second song.**
    
    a) Yes  
    b) No

12. **Which one do you prefer?**
    
    a) First  
    b) Second

13. **Are the movements according to the music? First Song.**
    
    a) Yes  
    b) No

14. **Are the movements according to the music? Second song.**
    
    a) Yes  
    b) No

15. **How do you feel about the song duration?**
16. How do you feel about the feedback of movements?
   a) very good  
   b) good  
   c) more or less  
   d) bad  
   e) very bad

17. How do you feel about the number of movements in each exercise?
   a) I feel very comfortable  
   b) I feel comfortable  
   c) I don’t feel comfortable or uncomfortable  
   d) I feel uncomfortable  
   e) I feel too uncomfortable

18. Do you like the scenario of the activity?
   a) very good  
   b) good  
   c) more or less  
   d) bad  
   e) very bad

19. Do you feel comfortable with the elements that you have to wear in the experiment?
   a) I feel very comfortable  
   b) I feel comfortable  
   c) I don’t feel comfortable or uncomfortable  
   d) I feel uncomfortable  
   e) I feel too uncomfortable
10.7 Annex 7

SF-36 QUESTIONNAIRE

Name: ____________________ Ref. Dr: _________________ Date: __________

ID#: ______________ Age: _______ Gender: M / F

Please answer the 36 questions of the Health Survey completely, honestly, and without interruptions.

GENERAL HEALTH:

In general, would you say your health is:

1. Excellent
2. Very Good
3. Good
4. Fair
5. Poor

Compared to one year ago, how would you rate your health in general now?

1. Much better now than one year ago
2. Somewhat better now than one year ago
3. About the same
4. Somewhat worse now than one year ago
5. Much worse than one year ago

LIMITATIONS OF ACTIVITIES:
The following items are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?

Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports.

1. Yes
2. Limited a lot Yes
3. Limited a Little No
4. Not Limited at all

Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf

1. Yes
2. Limited a lot Yes
3. Limited a Little No
4. Not Limited at all

Lifting or carrying groceries

1. Yes
2. Limited a lot Yes
3. Limited a Little No
4. Not Limited at all

Climbing several flights of stairs

1. Yes
2. Limited a lot Yes
3. Limited a Little No
4. Not Limited at all

Climbing one flight of stairs

1. Yes
2. Limited a lot Yes
3. Limited a Little No
4. Not Limited at all

Bending, kneeling, or stooping

1. Yes
2. Limited a lot Yes
3. Limited a Little No
4. Not Limited at all

Walking more than a mile

1. Yes
2. Limited a lot Yes
3. Limited a Little No
4. Not Limited at all

Walking several blocks

1. Yes
2. Limited a lot Yes
3. Limited a Little No
4. Not Limited at all

Walking one block

1. Yes
2. Limited a lot Yes
3. Limited a Little No
4. Not Limited at all

Bathing or dressing yourself

1. Yes
2. Limited a lot Yes
3. Limited a Little No
4. Not Limited at all

PHYSICAL HEALTH PROBLEMS:
During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of your physical health?

Cut down the amount of time you spent on work or other activities
Yes No
Accomplished less than you would like
Yes No
Were limited in the kind of work or other activities
1. Yes
2. No

EMOTIONAL HEALTH PROBLEMS:
During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

Cut down the amount of time you spent on work or other activities
1. Yes
2. No
Accomplished less than you would like
1. Yes
2. No

SOCIAL ACTIVITIES:
Emotional problems interfered with your normal social activities with family, friends, neighbors, or groups?

1. Not at all
2. Slightly
3. Moderately Severe
4. Very Severe

PAIN:
How much bodily pain have you had during the past 4 weeks?
1. None
2. Very Mild
3. Mild
4. Moderate Severe
5. Very Severe

During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?
1. Not at all
2. A little bit
3. Moderately
4. Quite a bit
5. Extremely

ENERGY AND EMOTIONS:
These questions are about how you feel and how things have been with you during the last 4 weeks. For each question, please give the answer that comes closest to the way you have been feeling.

Did you feel full of pep?
1. All of the time
2. Most of the time
3. A good Bit of the Time
4. Some of the time
5. A little bit of the time
6. None of the Time

Have you been a very nervous person?
1. All of the time
2. Most of the time
3. A good Bit of the Time
4. Some of the time
5. A little bit of the time
6. None of the Time
Have you felt so down in the dumps that nothing could cheer you up?
1. All of the time
2. Most of the time
3. A good Bit of the Time
4. Some of the time
5. A little bit of the time
6. None of the Time

Have you felt calm and peaceful?
1. All of the time
2. Most of the time
3. A good Bit of the Time
4. Some of the time
5. A little bit of the time
6. None of the Time

Did you have a lot of energy?
1. All of the time
2. Most of the time
3. A good Bit of the Time
4. Some of the time
5. A little bit of the time
6. None of the Time

Have you felt downhearted and blue?
1. All of the time
2. Most of the time
3. A good Bit of the Time
4. Some of the time
5. A little bit of the time
6. None of the Time

Did you feel worn out?
1. All of the time
2. Most of the time
3. A good Bit of the Time
4. Some of the time
5. A little bit of the time
6. None of the Time

Have you been a happy person?
1. All of the time
2. Most of the time
3. A good Bit of the Time
4. Some of the time

SOCIAL ACTIVITIES:
During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives, etc.)?
1. All of the time
2. Most of the time
3. Some of the time
4. A little bit of the time
5. None of the Time

GENERAL HEALTH:
How true or false is each of the following statements for you?
I seem to get sick a little easier than other people
1. Definitely true
2. Mostly true
3. Don't know
4. Mostly false
5. Definitely false

I am as healthy as anybody I know
1. Definitely true
2. Mostly true
3. Don't know
4. Mostly false
5. Definitely false

I expect my health to get worse
1. Definitely true
2. Mostly true
3. Don't know
4. Mostly false
5. Definitely false
My health is excellent
1. Definitely true
2. Mostly true
3. Don't know
4. Mostly false
5. Definitely false