ROBOT NAO USED IN THERAPY:

Advanced design and evaluation

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ABSTRACT

Following with the previous work which we have done in the Final Research Project, we introduced a therapeutic application with social robotics to improve the positive mood in patients with fibromyalgia. Different works about therapeutic robotics, positive psychology, emotional intelligence, social learning and mood induction procedures (MIPs) are reviewed. Hardware and software requirements and system development are explained with detail. Conclusions about the clinical utility of these robots are disputed. Nowadays, experiments with real fibromyalgia patients are running, the methodology and procedures which take place in them are described in the future lines section of this work.

Keywords: therapeutic robotics; social learning; human-robot interaction; fibromyalgia

INTRODUCTION

Following with the previous work which we have done in the Final Research Project, we introduced a therapeutic application with social robotics to improve the positive mood in patients with fibromyalgia.

Fibromyalgia (FM) is a chronic musculoskeletal pain condition with unknown etiology, characterized by widespread pain accompanied by fatigue and disturbed sleep and mood. Patients remain symptomatic and do not improve over long periods of time once the disease is established. In addition, functional disability slowly worsens. Comorbidities with affective and anxiety disorders are common and it is associated with frequent medical consultation and work disability, resulting in high economic and social costs. Addressing FM from a multidimensional perspective seems to be more effective than from single approaches. The multidimensional perspective includes psychological programs as a promising treatment for FM. Information and Communication Technologies (ICT) can help to enhance the effectiveness of some components of treatment [18].

According to these, the principal aims of this work are:

- Implementation of an advanced and affective behaviors and positive emotions system in the NAO robot that helps to lift the people mood.
- Implementation of a human-robot feedback system.

Moreover, we have developed a system for a mindfulness session inside a therapeutic session with fibromyalgia patients. Evaluations of the system are running thanks to the collaboration of Labpsitec members, the positive phycology research group in the Jaume I University.

The background on which this project is based are first described in Chapter 1, which explains a brief overview about the basics of positive psychology and emotional intelligence, therapeutic robotics, mood induction and social learning.

In Chapter 2, the project requirements are showed. Furthermore, how these requirements have been achieved with the hardware and software development are described.

Chapter 3 describes the experiments which have been done to test the performance of the system.

Finally, the conclusions obtained are highlighted and the future lines are mentioned.

An additional chapter to explain the therapeutic narrative used in the mindfulness session is showed in Annex I.

References consulted and indexes of figures and tables presented in this work are listed in the last pages of this document.

1 BACKGROUND

1.1 THERAPEUTIC ROBOTICS

It has been demonstrated in so many cases the benefits of the therapeutic use of robotics. Therapeutic robots are social robots that are used to care people with behavioral, emotional or motor disorders, as well as chronic disease or are used in rehabilitation therapies. As social robots, they must follow the human social behaviors rules established to interact and communicate with others. A review is given in [1].

Chronic illnesses can lead to a number of behaviors that respond to emotional reactions such as anxiety (when the risk factor is important), anger (when considering an unjustified attack) and guilt (if they try to explain the disease based in any cause) or depression (if it is interpreted as a loss or damage). Social robots can establish a successful long-term relationship with people and have already been proposed as a complementary tool for rehabilitation, autism therapy, adherence and compliance, and even to provide entertainment [132]. PARO, Keepon, Cosmobot, Kaspar and Kismet are some examples of such robots (Fig. 1).

Figure 1. From left to right and up to down: PARO, Keepon, Cosmobot, Kaspar and Kismet.

Pain and anxiety treatment based on social robot interaction is described in [6]. The aim of this article is to introduce a proposal to design pioneering techniques based on the use of social robots to improve the patient experience by eliminating or minimizing pain and anxiety with pet robots. This project will serve as well to develop a battery of assessment instruments to determine the impact of the program on their quality of life, which could be applied to other programs of quality of life.

In recent years, the robot NAO has also begun to be used as a therapeutic robot to improve the social interaction in children with autistic syndrome disorders (ASD), as is described in [55], [56] and [57]. A social robot must be able to communicate and interact with people and other agents with a physical structure, called embodied agents. The communication can be through verbal and non-verbal language. Verbal language can be expressed through writing or orally through speech. Non-verbal language can be expressed through gestures and movements. Since this robot is able to perform a lot of movement and it can talk, it has the essential features to communicate with others. A further therapeutic application of the robot NAO can be found in [33].

Figure 2. Robot NAO interacting with an ASD child

1.2 POSITIVE PSICHOLOGY AND EMOTIONAL INTELLIGENCE

This work is fundamentally based on the positive psychology and emotional intelligence principles. A full description about these currents are presented in [1]. Here, we will focus in the three ways designed by Seligman to achieve a full life, the human strengths study and the study of positive emotions.

1.2.1 How to achieve a full life

Seligman suggests that there are three ways to achieve a full life [10]. The first is through positive emotions (pleasant life), which means that happiness can be achieved in the present through the savoring and mindfulness, by focusing on the past if gratitude and forgiveness is cultivated or in the future, through the optimism and hope. The second way is the good life (engagement). This is based on testing of positive emotions. The third way is to have a meaningful life. This is the highest stage of happiness and the most durable. It consists in putting our skills and virtues to the service of some goal beyond ourselves for a vital significance as a result of this process.

1.2.2 The study of human strengths

The VIA classification of strengths project has resulted in a ranking of 24 fortresses and various assessment tools, that are available on www.psicologiapositiva.org page. Here, we show the VIA Classification of Strengths taken from [65].

1. Wisdom and knowledge: creativity, curiosity, open-mindedness, love of learning and perspective.
2. Courage: authenticity, value, persistence and vitality.
3. Humanity: kindness, love and social intelligence.
4. Justice: equity, leadership and teamwork.
5. Containment: ability to forgive, modesty, prudence and self-regulation.
6. Transcendence: beauty and excellence appreciation, gratitude, hope, humor and religiosity.

1.2.3 Study of positive emotions

This is a route through positive emotions to get to know the way you can increase the amount of positive emotions to achieve happiness.

It is emphasized in [13] that it is important to note that positive emotions are labeled as positive because they create a pleasant sensation, not because they are necessarily positive from an adaptive point of view. Among other effects, research has shown that positive affect enhances the ability to solve problems, increases creativity, enhances the ability to withstand pain, increases altruism, etc... (see [66]). Indeed, the theory of expansion and construction suggests that positive emotions may have as main function to develop new skills and behaviors [67].

1.2.3.1 Emotions

Oxford English Dictionary defines emotion as *"agitation or disturbance of mind; feeling; passion; any vehement or excited"* state of mind.

[11] is the best book in which emotions and emotional intelligence are described in detail that is why the following sections are mainly based on it.

There are two emotions models: the discrete model and the dimensional model. The discrete model or basic categories model supports that the emotional space is formed by a set of discrete and specific affective states that are easily recognized and distinguished between them [68-73]. However, researchers are still in disagreement over what can be considered as primary emotions. Some of the most popularized emotions are the proposed by Ekman:

- Anger
- Sadness
- Fear
- Happiness
- Surprise
- Disgust

The second model is usually based on the idea that the emotion can be perceived through the three affective dimensions (PAD) that are Pleasure (P), Arousal (A) and Dominance (D). The 3D emotion mapping based on the Miwa mental model and the PAD in [22] is showed in the figure below:

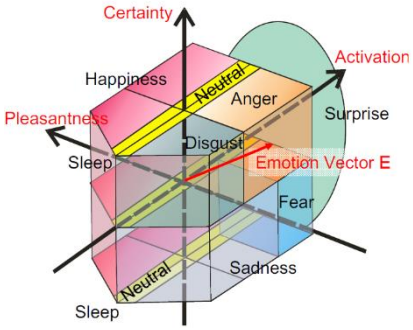

Figure 3. 3D emotion mapping in [22]

1.2.3.2 The expression of emotions

The ability to express a feeling is an essential social skill. Learning this deployment of roles takes place at a very early age. One of them is to minimize the emotions in the presence of an authority figure. Another is to exaggerate one feeling magnifying emotional expression, like children complain to his mother. A third is to replace a feeling for another (something that usually takes place, for example, in those Eastern cultures in where say 'no' is considered rude and instead, false positive emotions are expressed).

Empathy is the ability to tune emotionally with others. The key that allows us to access to the emotions of others is the ability to capture the non-verbal messages (tone of voice, gestures, facial expression, etc.). A survey of 1,011 children showed that those who were better able to read non-verbal emotional messages had a greater emotional stability. Unlike the rational mind, which is communicated through the words, the emotions do it non-verbally.

However, extremes never are so good. On one hand, one should keep in mind that excessive empathy can be harmful. The overflow perceived negative emotions, the feeling of inadequacy and not knowing self-regulate these emotions and feelings can cause what is known as empathic suffering. On the other hand, there are some people who are unable to perceive the feelings of others. These persons have alexithymia.

Empathy in human-robot interaction

According to [32], it is possible to build robots that appear to show empathy, which is commonly understood as the capacity to "put your-self in someone else's shoes to understand his/her emotions." Empathy research indicates that it is made possible by a special group of nerve cells called mirror neurons, at various locations inside the brain. Mirror neuron activity helps people understand actions and intentions of others and is also involved in understanding emotions. Empathy may be facilitated through a process of automatic mapping between self and other. Perception of the actions and emotions of others activates areas in our own brain that typically respond when we experience those same actions and emotions. Here, based on the Plutchik's theory of emotions, eight types of basic emotions are created by setting angles of the joints of the robot NAO.

1.2.3.3 The expressiveness and emotional contagion

The degree of emotional harmony experienced by a person in a certain match is reflected in how they adapted to their physical movements of their partner. The unconscious emotions you see displayed by another person are played through a process of unconscious imitation of the movements of his facial expression, gestures, tone of voice and other non-verbal indicators of emotion. Through this process, the subject itself recreates the mood of the other person. John Cacioppo, who has studied this type of emotional exchange [133], said that *"we do not understand or mimic the facial expression, just to see someone express an emotion to evoke the same mood. And it is this synchronization moods that determines you feel good or bad in a particular relationship."*

1.2.3.4 Lifts Mood

Sadness is the most mood people want to delete. However, not all sadness should be avoided because it has its positive aspects. Sadness can provide refuge from the cares and occupations of daily life in a period to assimilate them, conduct the relevant psychological adjustments and finally, to establish new plans that allow our lives move on. But while sadness is useful, however, depression is not. Therefore, it is needed to know the main mood elevators.

Crying, for example, can be a natural method to reduce the levels of brain neurotransmitters that feed anxiety. But it can also haunt the person because of his affliction. Distraction, however, is able to break the chain holding gloomy thoughts to depression. Wenzlaff [134] adds that the most effective distractions are those that can change our mood, for example, an exciting sports event, a funny movie or an interesting book.

According to Tice, aerobics is one of the most effective ways to shake off both mild depression and other negative moods. The effectiveness of the exercise seems to lie in their power to change the physiological condition caused by mood: depression is a state of low activation while aerobics, however, raises the body tone. For the same reason, relaxation techniques, which reduce the overall level of activation physically working properly for treating anxiety.

One of the most effective antidotes to depression - rarely used, of course, outside the context of therapy - is called cognitive restructuring or, in other words, try to see things from a different perspective.

1.2.3.5 The power of positive thinking

When people tend to worry directly hinder the process of decision making. The optimal relationship between anxiety and performance is achieved with the minimum nervousness that reaches the maximum performance.

In the same range of intellectual skills, emotional competencies are those that establish the differences. According to modern scholars, hoping not only provides comfort to the grief but also plays a very important role. Technically speaking, the hope is more than the naive view that all will be well. From the emotional intelligence point of view, hope means that somebody who has anxiety, depression or defeatism does not surrender when facing difficulties and setbacks. In fact, the hopeful people are less depressed in navigating through life in pursuit of their goals and are less anxious in general and experience less emotional stress.

Optimism means to have a strong expectation that, in general, things will go well despite the setbacks and frustrations. From the emotional intelligence point of view, optimism is an attitude that prevents falling into apathy, despair or depression face of adversity. And as like as hope, optimism, if it is a realistic optimism (the naive optimism can be disastrous), has its benefits.

'No pessimist has discovered the secret of the stars, or sailed uncharted seas, or opened a new doorway to the human spirit.'
Hellen Keller, Optimism, 1903.

As is showed in [17], research indicates that the Optimistic Explanatory Style predicts better overall health and less vulnerability to physical illness [137].

In 1974, the psychologist Robert Ader discovered that, like the brain, the immune system is able to learn [135]. This discovery has led to a new science called psychoneuroimmunology (PNI), currently at the forefront of medicine. Since then, a number of researchers have found that the most active chemical

messengers in both the brain and the immune system, are concentrated in the regions of the nerve responsible control of emotions. David Felten has provided some of the most conclusive in favor of the existence of a direct physiological link between emotions and the immune system tests [136]. Stress therefore decreases the immune resistance, at least provisionally. Microbiologists and other scientists have generally followed increasingly discovering connections between the brain, the cardiovascular system and immune system.

There is growing evidence that depressed patients who are suffering from a serious illness should also receive treatment for their depression. Depression seems to be a particularly serious medical risk for heart attack survivors. It has also been noted that depression can hinder the process of recovery from hip fractures.

Therefore, one of the most effective preventive measures is to help the person to lead his disturbing feelings (such as anger, anxiety, depression, pessimism and loneliness). There are some hospitals that have developed programs to help patients to alleviate their fears and willingly assume any inconvenience, teaching relaxation techniques.

1.2.3.6 In the present: mindfulness and savoring

The savoring is the full consciousness of pleasure, conscious and deliberate attention to the experience of the pleasure [138]. These authors highlight five techniques that promote enjoyment sharing with others, save memory, self-praise, sharpen perception and self-absorption.

Mindfulness is a mental state that is reached through training characterized by concentrating in our thoughts, feelings or actions. This type of care allows us to learn to interact directly with what is happening in our lives in the present moment, here and now, making us aware of our reality, and the potential challenges of life, such as pain, loss or illness. If mindfulness practice can develop greater capacity for discernment, compassion, and help us to walk in the here and now, that is, to experience a full life in the present.

As a psychological concept is the focusing of attention and awareness. Clinical psychology and psychiatry since the 1970s have developed a number of therapeutic applications based on mindfulness for helping people suffering from a variety of psychological conditions, and research has found therapy based on mindfulness to be effective, particularly for reducing anxiety, depression, and stress.

Bishop, Lau, and colleagues [74] offered a two-component model of mindfulness. The first component involves the self-regulation of attention so that it is maintained on immediate experience, thereby allowing for increased recognition of mental events in the present moment. The second component involves adopting a particular orientation toward one's experiences in the present moment, an orientation that is characterized by curiosity, openness, and acceptance. In this two-component model, self-regulated attention (the first component) involves conscious awareness of one's current thoughts, feelings, and surroundings, which can result in metacognitive skills for controlling concentration. Orientation to experience (the second component) involves accepting one's mind stream, maintaining open and curious attitudes, and thinking in alternative categories (developing upon [139]). Practicing mindfulness can help people to begin to recognize their habitual patterns of mind, which have developed out of awareness over time and this allows practitioners to respond in new rather than habitual ways to their life.

Since 2006 research supports promising mindfulness-based therapies for a number of medical and psychiatric conditions, notably chronic pain [75], stress [76], anxiety and depression [77], substance abuse [140], and recurrent suicidal behavior [78]. Bell [79] gives a brief overview of mindful approaches to therapy, particularly family therapy, starting with a discussion of mysticism and emphasizing the value of a mindful therapist.

Mindfulness-based stress reduction includes a variety of meditation techniques including body awareness and breathing exercises.

Mindfulness-based Cognitive Therapy (MBCT) psychotherapy combines cognitive therapy with mindfulness techniques as a treatment for major depressive disorder and many other disorders. Steven C. Hayes and others have developed Acceptance and Commitment Therapy (ACT), originally called "comprehensive distancing", which uses strategies of mindfulness, acceptance, and behavior change.

Mindfulness is a “core” exercise used in Dialectical Behavior Therapy (DBT), a psychosocial treatment Marsha M. Linehan developed for treating people with borderline personality disorder. DBT is dialectic, explains Linehan [141], in the sense of “the reconciliation of opposites in a continual process of synthesis.”

1.2.3.7 MOOD MEASURES

We have some different ways to measure the emotions [13, 14]. Among the instruments most commonly used are the self-evaluation tests such as the PANAS (Positive and Negative Affect Schedule) made by [80], which has 20 items to assess positive affect. In its expanded version consists of 55 items [81].

The Diener research group built two new instruments [82], the Späne P and N (positive and negative experience) to assess both positive and negative emotions.

Other instruments are kind of checklist in which to assess one dimension are considered and evaluated several items have to address whether the emotion in question is present or not. One of the best known in this area is the Multiple Affect Adjective Checklist-R [83].

Other questionnaires that assess positive affect are actually personality questionnaires. In this case we have the Multidimensional Personality Questionnaire Tellegen (*1982*) [84]. Among these we find the on-line methods in which the person carries a pager or alarm and must complete a predominant emotions questionnaire when he is informed [85].

Some researchers considered useful to assess facial features as markers of emotions. Ekman and Friesen (1978) devised a method for encoding face images based on facial muscle movements [86].

Finally, another method widely used to assess positive emotions is the memory of pleasant events in a given time period. The highest frequency of remembered events are indicators of positive affect [87].

The most useful tools to assess satisfaction with life, understood as the cognitive component of well-being, are generally self-reports. The most commonly used for the evaluation of the satisfaction with life scale is the SWLS (Satisfaction with Life Scale) [88]. The TWLS (Temporal Life Satisfaction Scale), leading to the evaluation of past and future satisfaction [89]. For the assessment of satisfaction in older populations a widely used instrument is the Life Satisfaction Scale [90]. Another very commonly used instrument to assess satisfaction with life together with the emotional dimensions of wellness is the Oxford Happiness Inventory [142] of 29 items.

Other widely used tools is the Fordyce Happiness Measures [91], the Authentic Happiness Questionnaire (evaluates overall happiness), the CES-D Scale (evaluate depressive symptoms) and the General Happiness Scale (evaluates overall happiness).

In other papers we can find other ways to evaluate the emotion perceived through the three affective dimensions (PAD), which are Pleasure (P), Arousal (A) and Dominance (D). We can see an example in [41].

1.3 MOOD INDUCTION

Mood Induction Procedures or MIPs are methods to induce some emotions in people causing a transition in an individual's emotional state into an unnatural situation in a controlled manner. Experimental research in this field are grouped into the following classes: Velten MIPs [92], Imagination MIPs [93], Autobiographical memories MIPs [94], Film/Story MIPs with and without instructions [95-97], Music MIPs with and without instructions [143], Sounds MIPs [98, 100], Visual MIPs [99], Feedback MIPs, Social Interaction MIPs [101], Gift MIPs, Facial Expression MIPs [102], and Combined MIPs. Other procedures less used are for example, mood induction by hypnosis [103]**,** drugs or even smells, which appear in some studies although it is evident its limitations for positive and negative mood induction [104].

1.3.1 Velten MIP

The first MIP was developed by Velten in 1968. This self-referent-statement technique is by far the most widely used MIP. Sixty statements describing either positive/negative or neutral self-evaluations,

written in the first person, were intended to induce: positive (ex: 'I feel really good'), negative (ex: 'I feel disappointed with myself') and neutral (ex: 'This book or any part thereof may not be reproduced').

Nowadays, it exists a standard procedure that using words lectures to induce emotions, the Affective Norms for English Words (ANEW), [105].

1.3.2 Imagination MIP

In this class of mood induction procedures, it is assumed that moods can be induced by imagining emotion-ridden events. Subjects are instructed to imagine situations from their lives that had evoked the desired mood [106-107]. In addition, they are usually asked to imagine vividly and try to re-experience the original perceptions, sensations, and affective reactions. To intensify this process, they are sometimes instructed to write down the imagined event and to elaborate the related thoughts and feelings. In a very few cases, the type of event to be imagined is prescribed.

1.3.3 Autobiographical memories MIP

It consists in mental images, particularly emotional. Lang concludes that such images can be controlled and modified through input and output variables, to be encoded in memory in the form of propositions that are organized in associative networks. For Lang input variables are verbal instructions, the output variables are the different reactions.

1.3.4 Film-Story MIP

In this class of mood induction procedures, some narrative or descriptive material are presented to subjects to stimulate their imagination. The presentation of stones and films is subsumed into one class of MIPs because in both cases subjects may identify with certain protagonists. The complexity of the stimulus material differs considerably and covers elaborate stones, short scenes from a film, descriptions of scenarios, etc. The Film/Story MIP is employed either with or without explicit instruction. In the Film/Story + Instruction MIP, subjects are explicitly asked to imagine and 'get involved' in the situation described and in the feelings suggested.

1.3.5 Music MIP

In the Music + Instruction MIP, subjects listen to a mood-suggestive piece of classical or modern music after being instructed to try to get into the mood expressed by the music. Usually the experimenter determines the kind of music used for the induction. In some studies, however, each subject is given the opportunity to choose the piece of music that he or she judges to be best suited for putting him or her into the intended mood. The Music MIP without instruction simply presents a piece of music without emphasizing its emotional character.

1.3.6 Sounds MIP

The International Affective Digitized Sounds (IADS-2) was developed to provide a set of normative emotional stimuli for experimental investigations of emotion and attention. This version of the IADS-2 includes ratings for 167 sounds, which were rated in 3 separate rating studies. We can see in [52] the mean ratings for these sounds for all subjects, for female subjects and for male subjects.

1.3.7 Visual MIP

There is an International Affective Picture System (IAPS). It has been developed by Lang in the University of Florida with the aim to offer a standard set of emotional stimuli to the scientific community. This set is formed by photographs in color for induce emotions which contents cover about a wide range of categories [108]. Furthermore, a standard measure is provided to facilitate the comparison between different research laboratories.

1.3.8 Feedback MIP

Since mood can be influenced by experiences of success or failure, in some studies subjects are given positive or negative feedback on their performance on a test.

Other feedback MIP is the respiratory feedback which is based on the reproduction of respiratory patterns associated with the emotion that is meant to induce. With this method [109] achieve an auto-informed intensity of 47% in happiness, fear, sadness and anger.

1.3.9 Social Interaction MIP

In order to induce a positive or negative mood state, subjects are exposed to certain social interactions arranged by the experimenter. Usually subjects interact with a confederate trained to behave in a depressed, an elated, or a neutral manner. The assumption here is that the behavior of others will affect one's own emotional state. In some studies [110], subjects are given the opportunity to 'help' a friend of the experimenter, figuring that people feel good after having helped another person.

1.3.10 Gift MIP

Usually subjects receive a small gift and are told that the gift was a token of appreciation for participating in the experiment.

1.3.11 Facial Expression MIP

Following the facial feedback hypothesis [111], some experimenters manipulate the expression of their subjects' faces in order to induce certain mood states. Subjects are instructed on how to contract and relax different facial muscles to produce a frown, a smile, a neutral face, etc. To obscure the purpose of this procedure, subjects are often told that the experiment is concerned with measuring muscular activity while performing cognitive and perceptual tasks.

1.3.12 Combined MIP

To increase the effectiveness of the induction, some authors combine different types of MIPs. Especially suited for such a combination are procedures that are similar to one another, for example the Velten and Imagination MIPs or the Velten and Music MIPs can be applied simultaneously. An example is described in [47].

1.3.13 The Demand Effect

The so-called "demand effect" of the task can be placed in MIPs with instructions. Some research suggest that manual handling techniques can have higher efficacy when explicitly inform the subject about the goals of the MIPs which would invalidate the results of the investigations. But the question of demand characteristics with respect to mood induction procedures is still under debate and thus deserves further investigation.

1.3.14 Effectiveness and validity of the different MIPs

It is assumed that the emotional response is predicted quite likely that a particular situation will induce most subjects and subsequently through statistical analysis, the range of validity of the method used is determined.

There is some evidence of systematic differences between subjects in their susceptability to certain MIPs. Gouaux reported in their influential study in 1971 that women are more susceptible to the effects of the Velten technique than men.

Evidence indicates that MIPs give rise to multiple affective states instead of producing particular, pure emotions. Several investigators, using multiple affect inventories to test the effectiveness of the mood induction, found elevations in affects additional to the target emotion [112]. Polivy , reviewing the literature relating to the specifity of induced mood states, pointed out that especially the negative emotions of depression, anxiety, and hostility appear to covary [144]. Accordingly, *"we should be aware that our investigations of "an emotion" are most probably investigations of several simultaneous emotions"*.

Discrepant evaluations of the effectiveness of mood induction procedures are given especially in the case of the Velten MIP. Goodwin and Williams [113] conclude that the Velten procedure *'is a potent manipulator of mood…'*. According to [114], the Velten and Facial Expression MIPs achieve an average success rate of 50 per cent, whereas the Imagination, Film, and Music MIPs induce the required mood in more than 75 per cent of the subjects.

In [55], the effectiveness and validity of important mood induction procedures (MIPs) were comparatively evaluated by meta-analytical procedures. Two hundred and fifty effects of the experimental induction of positive, elated and negative, depressed mood in adult, nonclinical samples were integrated. Secondly, they analyzed the effects of MIPs for different kinds of manipulation check measures. Effects were expected to be larger for self-reports than for behavioral measures. In addition, they wanted to compare the results of studies that use special self-constructed scales with those using standard mood or depression scales. Finally, they wanted to test whether the effects of the mood induction procedures depend on the control of demand effects, the sex and profession of the subjects, and other supposedly relevant study characteristics. Effect sizes were generally larger for negative than for positive mood inductions. The presentation of a film or story turned out to be most effective in inducing both positive and negative mood states. The effects are especially large when subjects are explicitly instructed to enter the specified mood state. For the induction of negative mood states, Imagination, Velten, Music are the most effective procedures. Social Interaction and Feedback MIPs were about as effective as the Film/Story MIP without instruction. According to these results, the Film/Story + Instruction MIP is clearly the most potent procedure for the induction of both elated and depressed mood. If it is intended to induce positive as well as negative mood states in the same study, the Film/Story without instruction MIP also can be recommended. For the induction of positive mood, these two procedures should be first choice, as all the other MIPs yielded clearly lower effectiveness scores. For the induction of negative mood, however, the other MIPs except the Facial Expression MIP also proved to be rather effective. Effects tend to be smaller when demand characteristics are controlled or subjects are not informed about the purpose of the experiment. For behavioral measures, effects are smaller than for self-reports but still larger than zero. Hence, the effects of MIPS can be partly, but not fully due to demand effects. Some of the recommended procedures explicitly ask subjects to enter a certain mood state. For these procedures in particular, demand effects cannot be ruled out. Thus, if demand effects are considered to be a serious threat to the validity of an experiment, MIPs that do not inform subjects may be preferable.

In [47] possible differences between the induction of two states of mind, happy and sad, and four MIPs, Music, Remember + Music, Velten and Velten + Music are analyzed. Forty subjects were randomly assigned to the four experimental groups of 10 each. They were told they would participate in research on semantic relations. Each subject performed two individual sessions with an interval of one week between them. He asked subjects not to discuss with anyone what they had done in each session. Three Scale self-assessment of mood where used which were ten Likert Scale points where the participants assess their mood between very sad (10) and happy (0). Various ANOVAs were performed to analyze possible differences. When significant differences were a post hoc test was applied to analyze the direction of these differences (Scheffé multiple range test). The results showed that both were effective in inducing moods and no differences in efficacy were found between them. Moreover, it was easier to induce a sad mood than a cheerful mood. If we considering network theory of memory Bower on emotion [115-116], it may be that the activation of the "negative" emotional nodes occurs more easily and faster than the activation of the "positive" emotions.

In [54] two MIPS, autobiographical recall and combined MIP, are compared inducing changes in arousal and valence. Participants were randomly assigned either to an autobiographical recall or to a music and guided imagery MIP and underwent a happiness, serenity, anger, or sadness mood induction. Some differences appeared between the two MIPS used in our study. On the one hand, autobiographical recall was very effective in inducing the four specific moods. On the other hand, the combined MIP led to more complex results. The combined MIP fostered changes in the valence dimension for anger and sadness inductions, but also for serenity induction. However, this MIP failed to produce changes in the happiness induction. When looking more closely at the results, one explanation for this absence of change from pre to post-induction in the valence dimension for the happiness induction could be that some of the participants may already have been as happy as possible prior to induction. When participants begin experiments in a positive mood state, this positive mood state is then hard to enhance.

In the visual MIPs evaluations, [60] highlights. It is a Spanish adaptation of the effects in the valence, arousal and dominance affective dimensions of the IAPS. Here, 1102 university students look at the first eight sets of the IAPS and then fill in a Self-Assessment Manikin [117]. The results are showed in tables.

Another work that review the effects caused by different MIPs is [53]. The table 1 that is displayed below shows the most important data:

Table 1. Review of different MIPs

Method	Studies revised	Effectiveness*	Trustful interval
Film segments	162	0.6	[0.53, 0.66]
Pictures	25	0.81	[0.58, 1.03]
Music	49	0.53	[0.41, 0.65]
Velten	93	0.51	[0.44, 0.58]
Imagination	73	0.51	[0.42, 0.61]
Reading texts	19	0.41	[0.29, 0.53]
Expression and emotional behavior	24	0.47	[0.34, 0.60]
Real life experiences	105	0.46	[0.37, 0.54]
Autobiographic memories	36	0.45	[0.39, 0.51]

***Hedges g: up to 0.2 low; 0.3-0.7 moderate; more than 0.8 high.**

[58] describes an effectiveness comparison between different MIPs: Imagination manipulated, Velten, Film/Story with and without instructions, Music with and without Instructions, Successes and failures manipulation, Social Interaction, Gifts, Facial Expression manipulated and Combined. The results showed that the Film/Story + Instructions is the most effective way to induce both positive and negative emotions, achieving greater efficiency in the positive answers. This suggests the high efficiency of the "demand effect".

The Spanish adaptation of the Affective Norms for English Words (ANEW) is presented in [57]. It can be downloaded at www.psychonomic.org.The evaluations in this article were done in the dimensions of valence, arousal and dominance using the Self-Assessment Manikin (SAM). Another work related to this is [51] in which 253 students evaluated the affective dimensions of valence, frequency and activation of 238 Spanish substantives.

It can be possible the vocal communication of emotion too, as is described in [59]. Most studies in the vocal effects of emotion choose to examine the effects of happiness, sadness, fear, anger and surprise. Emotion effects on voice and speech is reviewed and issues for future research efforts are discussed. Special emphasis is placed on the conceptualization and operationalization of the major elements of the model (i.e., the speaker emotional state, the listener attribution, and the mediating acoustic cues). In addition, the advantages and disadvantages of research paradigms for the induction or observation of emotional expression in voice and speech and the experimental manipulation of vocal cues are discussed. Results are summarized in a table which indicates for example that the two positive moods of elation/joy and happiness/enjoyment can be discriminated through the speech rate and the transition time between words.

[49] is other article that it must be highlighted. Here, affective ratings of sound stimuli is presented. It presents the Spanish assessments of the 111 sounds included in the International Affective Digitized Sounds [57]. The sounds were evaluated by 159 participants in the dimensions of valence, arousal, and dominance, using a computer version of the Self-Assessment Manikin. Results are compared with those obtained in the American version of the IADS, as well as in the Spanish adaptations of the International Affective Picture System [60] and the Affective Norms for English Words [57]. Results shows that although American and Spanish sample populations evaluated IADS sounds in a highly similar way, it is also true that some slight differences have been found that should not be overlooked. In fact, the same happened with the IAPS and ANEW. We now know that Spanish people show a stronger emotional reactivity (arousal) across stimuli; they tend to assess words and sounds, but not images, as being slightly more unpleasant (valence) than do Americans; and, finally, the Americans show a higher feeling of control (dominance) over emotional images and words, but not over sounds.

We consider you have to know what [8] is about. This recent study aims to investigate whether emotion simulation is also involved in online and offline comprehension of larger language segments such as discourse. Participants read a target text describing positive events while their facial postures were manipulated to be either congruent (matching condition) or incongruent (mismatching condition) with emotional valence of the text. In addition, read the text naturally. The influence of emotion simulation on discourse understanding was assessed by online (self-paced reading times) and offline (verbatim and inference questions) measures of comprehension. The major result was that participants read faster the target text describing positive emotional events while their bodily systems were prepared for processing of positive emotions (matching condition). Discourse Comprehension and Simulation of Positive Emotions body is inextricably linked to the mental process and appears central to the representation of meaning.

Finally, how appraisals shape our emotions can be read in [48]. Appraisal theories of emotion hold that it is the way a person interprets a situation -rather than the situation itself- that gives rise to one emotion rather than another emotion (or no emotion at all). In this study, participants responded to a standardized laboratory situation with a variety of different emotions. Together, these findings suggest that appraisals may be necessary and sufficient to determine different emotional reactions toward a particular situation. The first version holds that different appraisal profiles are sufficient conditions to evoke different emotional reactions toward the same situation, that is, different appraisals are all that is needed to evoke different emotions, even if all other circumstances are the same. The second version holds that different appraisal profiles are necessary conditions to evoke different emotional reactions toward the same situation, that is, the same situation cannot evoke different emotions unless it is appraised differently. Six emotions that were expected to be induced by the situation were measured with the items "guilty", "shameful", "sad", "angry", "amused" and "pleased" on an 11-point scale ranging from 0 (none at all) to 10 (extremely). Next, participants completed an appraisal questionnaire containing five fundamental appraisal dimensions that are postulated in a variety of appraisal theories [118-123]: controllability ("I felt in control of what happened during the previous task."), self-importance ("The previous task was important to me."), unexpectedness ("What happened during the previous task was unexpected."), other-responsibility ("What happened during the task was the responsibility of the experimenter."), and self-responsibility ("I could have changed the way the previous task went."). Appraisals were measured on an 11-point scale ranging from 0 (strongly disagree) to 10 (strongly agree). The results showed that individual emotional reactions were determined by how people appraised the situation. Changing appraisals can be sufficient to influence the intensity of emotions. It is noteworthy that non-cognitive emotion regulation strategies, such as inhibition of emotion expressions, have been consistently found to be less efficient to change the intensity of emotions. If appraisals are necessary for the generation of emotions, changes in appraisals may be necessary to change emotions, showing that reappraisal cannot only change the intensity of an emotion but also its quality could substantially add to the contribution of emotion regulation research to appraisal theories.

1.3.15 New technologies applied in MIPs

New technologies allow a new way to induce emotions.

Virtual reality (VR) has been used in some studies to induce positive emotions. This is the case of OncoHelp, a virtual reality system leading to the emotional wellbeing in oncology patients hospitalized. The OncoHelp Phase II is described in [56]. Various methods of emotional induction (narrative, audio, pictures, self-referential sentences, etc…) are presented in the virtual environment which has features specifically designed for the promotion of the emotion you want to promote (music, color, sound, lighting, elements of nature). During the tour crossing a park you can hear the cheerful music piece 'Eine kleine Nachtmusik' by Mozart and a relaxing melody that accompanies other activity, "Heavenly Theme" by Michael Lindh. The patient is guided by audio narratives to perform various activities. These activities are:

1) Self-referential 'Velten' phrases and emotional pictures from the International Affective Pictures System (IAPS). It proposes that the patient reflect on the meaning of each message, associating it with his personal history. The relaxing nature walk through the attention to auditory stimuli (birds singing, music, and water) is encouraged.

2) Slow Breathing: the patient is asked to perform an exercise in slow breathing, guided by audio narratives.

3) An autobiographical positive recall. The patient is encouraged to emotionally relive a funny situation of his life, recovering as much as possible the details of the event.

The experience you have with this system so far indicates that its implementation in the hospital setting may be feasible, as it represents the realization of short sessions and therefore able to adapt to the times and needs of the hospital routine. In addition, sessions are held in the same room of the patient, thereby allowing those patients who cannot move easily, also have access to this intervention. Preliminary results in an intervention shows better outcomes, reinforcing how promising such tool can be enhancing a greater emotional well-being. In view of the few VR applications aimed at the promotion of emotional wellbeing in oncological patients hospitalized, the implementation and testing of the system described is of particular clinical value, especially considering how relevant the hospitalization period in emotional and physical terms for these patients is. Since it is essential to provide a comprehensive treatment throughout the disease process, it is important to further investigate the utility of various tools to support the psychological intervention.

How manipulating mental states through physical action doing by a humanoid robot is showed in [5]. In this paper, Jesse Gray and Cynthia Breazeal present their implementation of a self-as-simulator architecture for mental state manipulation through its visual perception. The motivation for this work is to explore the connection between (hidden) mental states of an embodied agent and the (observable and modifiable) world in which they exist. The research here focuses on short timescale (0 to 60 seconds), highly detailed modeling of how the robot's actions will affect the human's mental states through the means of their perception. The scenario chosen for this demonstration revolves around a simple competitive game played between the human and the robot.

1.4 SOCIAL LEARNING

In accordance with Albert Bandura [61] social learning theory assumes that modeling influences produce learning principally through their informative functions and that observers acquire mainly symbolic representations of modeled activities rather than specific stimulus-response associations. In this formulation, modeling phenomena are governed by four interrelated sub processes:

- Attentional processes. A person cannot learn much by observation if he does not attend to, or recognize, the essential features of the model´s behavior.
- Retention processes. A person cannot be much influenced by observation of a model´s behavior if he has no memory of it.
- Motoric reproduction processes. The third component of modeling is concerned with processes whereby symbolic representations guide overt actions. To achieve behavioral reproduction, a learner must put together a given set of responses according to the modeled patterns. The amount of observational learning that a person can exhibit behaviorally depends on whether or not he has acquired the component skills. If he possesses the constituent elements, he can easily integrate them to produce new patterns of behavior, but if the response components are lacking, behavioral reproduction will be faulty. Given extensive deficits, the sub skills required for complex performances must first be developed by modeling and practice.
- The modeling process and transmission of response information. A major function of modeling stimuli is to transmit information to observers on how to organize component responses into new patterns of behavior. This response information can be conveyed through physical demonstrations, through pictorial representation or through verbal description. Much social learning occurs on the basis of casual or studied observation of exemplary models.

1.4.1 Social learning in human-robot interaction

In human-robot interaction the most social learning method used is the teacher-learner. The learner uses the teacher as a model. A simple imitative strategy is used as the social bonding mechanism.

One of the oldest works (1999) that are done in this field is [20]. This article addresses embodied social interaction in lifelike agents. 'Dancing with strangers' experiment shows how the same principles can be applied to physical robot-human interaction. The AURORA project for children with autism which addresses issues of both human and robotic social agents is introduced. This work is based on the following working hypotheses:

1. Life and intelligence only develops inside a body,
2. Which is adapted to the environment which the agent is living in.
3. Intelligence can only be studied with a complete system, embedded and coupled to its environment.
4. Intelligence is linked to a social context. All intelligent agents are social beings.
5. There is no memory but the process of remembering.
6. Memories do not consist of static items which are stored and retrieved but they result out of a construction process.
7. The body is the point of reference for all remembering events.

The long-term goals of the AURORA project are twofold: 1) helping children with autism in making the initial steps to bond with the (social) world, 2) studying general issues of human-robot interface design with the human-in-the loop, in particular a) the dynamics of the perception-action loop in embodied systems, with respect to both the robot and the human, b) the role of verbal and non-verbal communication in making 'social' interactions, c) the process of adaptation.

The conclusions are that scaling up from simple imitative behaviors like pre-programmed following (learning by imitation) towards 1) more complex forms of imitation and imitating robots, 2) learning to imitate is possible. And that it is better that robots can have the role of a 'social mediator' instead of replacing humans.

Later, in 2007, there were published another two works, [62] and [24], which describe a robotic system that uses dance as a form of social interaction to explore the properties and importance of rhythmic movement in general social interaction. The system consists of a small creature-like robot, Keepon, whose movement is controlled by a rhythm-based software system. Interactional synchrony provides a foundation for interpersonal coordination and emotional contagion. Imitation and pattern are recognized in anthropology and social science literature as the foundation of a 'dance' of coordinated sound and movement between interactors. The authors consider interactive dance with a robot as an activity that can be used by clinicians to study a child's behavioral patterns and identify rhythmic abnormalities that could be useful in diagnosing certain pathologies. Dance has, in turn, been identified and used in therapies for a wide range of disorders.

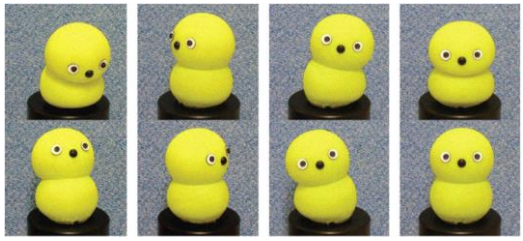

Figure 4. Keepon's four degrees of freedom (nodding, panning, rocking, and bobbing).

In [42] the objective is to study how a mobile robot can, by appearing more predictable, appealing and simple than a human being, facilitate reciprocal interaction such as imitative play. The AuRoRA project was attempting to use the robot to bridge the gap between the complex and unpredictable world of human social behavior and the safe predictable world of simple toys. A mobile robot, Tito (Figure 5), is used to navigate the robot and respond to the child's interaction through teleoperation. By conducting an exploratory study involving four children with low functioning autism (one pair with the robot mediator and the other with the human mediator) they found that forms of shared conventions such as imitation of body movements and of familiar actions are higher with two children paired with a human mediator, compared to two children paired with a robot mediator. However, the two children paired with the robot mediator demonstrated increased shared attention (visual contact, physical proximity) and imitate facial expressions (smile) more than the children paired with the human mediator.

Figure 5. Robot Tito

Other robot that has been used for developing an interactive learning is ASIMO. In [63] a pilot study attempted to determine which features in robots led to changes in learning and behavior were implemented into ASIMO to see if children can learn from robots. Promissory evidence shows that learning styles and general features matter especially for younger children. There are several important reasons why

humanoid robots are preferable social partners to learning. One reason is that humanoids have human-like appearance and behavior. Human-like appearance and behavior elicits strong social responses that invite active engagement. Social interaction plays an important role in learning, and has proven to be quite effective in collaborative learning, peer learning, reciprocal teaching, and behavior modeling. Psychological reasons are that humanoid features and gestures can potentially present a more natural communication interface for people. This pilot study is 1) a learning effectiveness study that determines if social interactions with robots lead to effective learning, and 2) a causal study that try to determine which properties in robots or in the social interaction lead to changes in learning and behavior. Children who interacted with the cooperative ASIMO learned more than the other conditions. Learned more when interacting with the human-like voice and index gesture ASIMO than the robot-like voice (monotone voice) minimal gesture ASIMO. The voice may have been the more important of the two factors, but further experiments are needed.

In [21] is demonstrated that in line with previous findings, children with ASD in their sample were quite often able to respond accurately to prompts delivered by a humanoid robot within the standardized protocol. Further, participants also spent a significant portion of the experimental sessions looking at the humanoid robot, replicating other work suggesting that young children with ASD show attentional preferences for robotic interactions over brief intervals of time. In addition, within this work they also documented that children could demonstrate improved performance over time in a basic core social communication skill and area of deficit (i.e., response to joint attention) and that over the course of sessions, children maintained interest in the humanoid robot NAO.

For a further review of the clinical use of robots for individuals with Autism Spectrum Disorders, please see [50].

In [23] the authors set up an interaction experiment in which participants could physically interact with a humanoid robot equipped with mechanisms for saliency detection and attention manipulation. They tested their implementation in four combinations of activated parts of the attention system, which resulted in four different behaviors. They adopted two techniques for evaluating saliency detection and attention manipulation mechanisms in human-robot interaction: user experience as measured by qualitative and quantitative questions in Godspeed questionnaire, which uses semantic differential scales for evaluating the attitude towards the robot (anthropomorphism, animacy, likeability, perceived intelligence and perceived safety) and proxemics estimated from recorded videos of the interactions. The robot platform which was used is NAO (version 3.3) and only the degrees of freedom in the arms and the neck were used. The results are displayed in the following graphics (Figure 6).

The robot's level of interactiveness has been found to be positively correlated with user experience factors like excitement and robot factors like lifelikeness and intelligence, suggesting that robots must give as much feedback as possible. However, an excessive human-like appearance can entail the interacting person having too high expectations about the robot's cognitive capabilities, which can provoke disappointment whenever the robot does not fulfill such expectations. We believe that the positive correlations between the anthropomorphic attributes and the perceived intelligence reflect a good balancing between NAO's human-like appearance and its implemented cognitive capabilities. Multi-modal interaction (through arm or head movements) increased the level of interactiveness perceived. Combining gestures and gazing for increasing the persuasiveness and the likeability of the robot matches our consideration about multi-modal interaction. Elegance in movement positively correlating with user satisfaction suggests that the robot might perform smooth and natural movements in order to increase the quality of the interaction.

Finally, the paper [19] shows the application of the playfully imitative interactions into child-robot interaction. Children imitated emotional behaviors of robot in aesthetic interactions. In other words, aesthetic imitative interactions make positive emotions. Gestures on their robot that uses upper body by driving the actuators of shoulder, elbow and neck were designed to represent the emotional meaning using the conditions of speed and intensity; light and slow for positive gestures, strongly and fast for negative gestures.

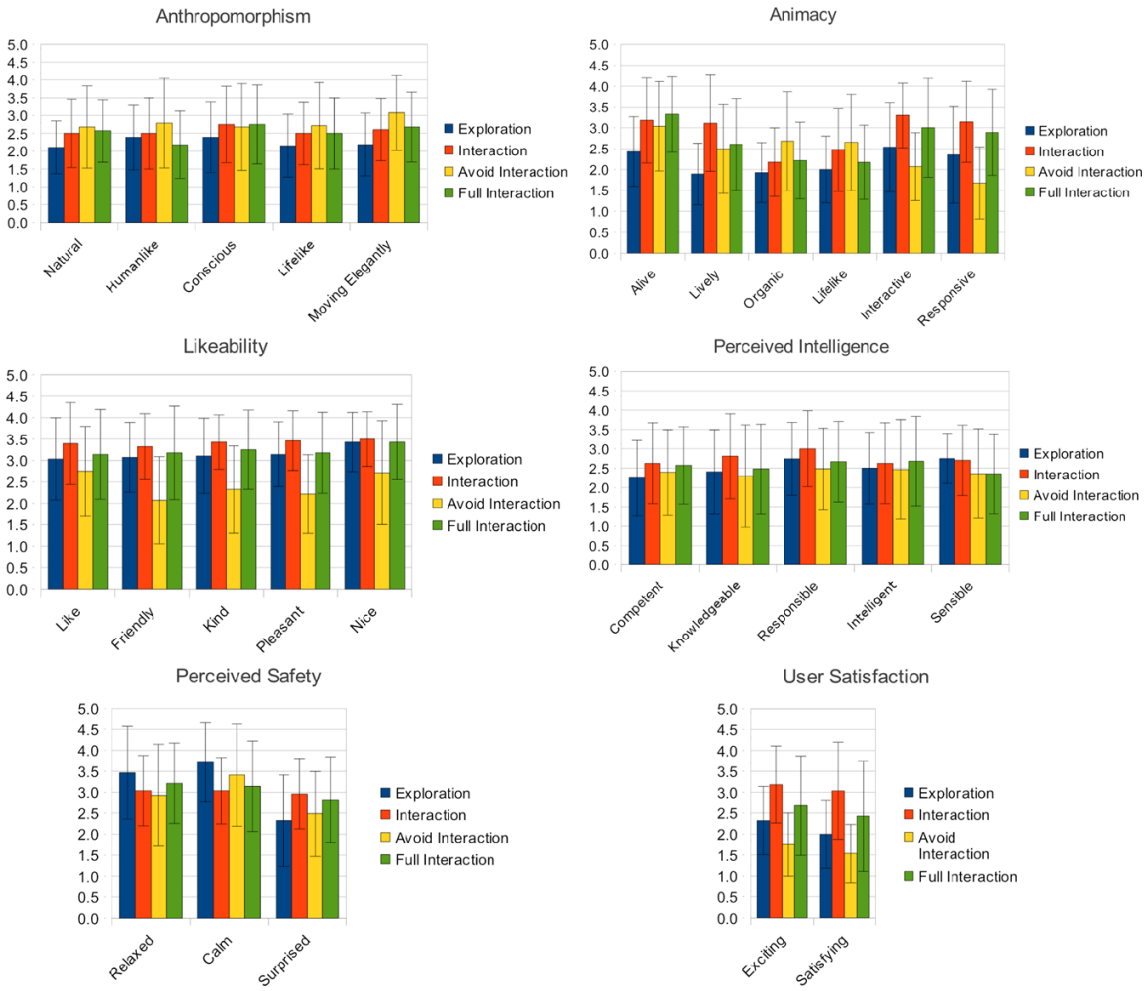

Figure 6. These graphs show the results taken from the Godspeed questionnaire

2 DEVELOPMENT

To make the system affordable for its use by therapists, we have selected for our application a medium-sized humanoid robot, such as Aldebaran Nao [40]. Furthermore, we think that its beatiful appearance, soft movements and the way it talks represent an advantage over other existing humanoids. Therefore, the main aim of this work is to implement an emotive system that allows the robot NAO to participate in a therapy lifting positive moods. In particular, NAO will develop the role as a co-therapist in a part of a psychologist session to increment and improve the positive moods with people who have fibromyalgia. Additionally, it must have a feedback system that allows the communication between the therapist and it.

NAO will present a mindfulness session when the therapist directed it and will guide people doing the principal instructions the video gives.

For more information about the mindfulness session please refer to Annex I.

2.1 REQUIREMENTS

Based on our hypothesis, our system was primarily designed to be applied in a Film MIP with instructions. In this way, to complete gratefully the mindfulness session as a co-therapist, NAO must be able to:

- Speak in an understandable and comprehensive way.
- Move according the things it is saying or it is hearing in the mindfulness video.
- Recognize the therapist instructions.
- All these previous requirements must be based in the positive psychology, the emotional intelligence, mood induction procedures, social learning, and the human-robot interaction principles.

For more information about the movements NAO must realize and the instructions it must recognize, please refer to Annex I.

2.2 HARDWARE

The humanoid robot NAO is used in this project. A detailed description of it can be viewed in the web page: http://www.aldebaran.com/en

The NAO hardware devices used for this proposition are highlighted in the figure below:

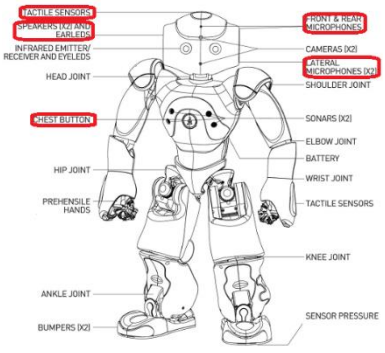

Figure 7. NAO hardware

Chest Button: to turn on and turn off the robot pressing it during 3-5 seconds approximately.

Front, rear and lateral microphones: to collect sound information, such as speech.

Speakers: to reproduce speech.

LEDs: to emit color lights.

Tactile sensors: to manage the parts of the narrative.

Motors: to move the joints forming different poses.

NOTE: microphones place must be noticed for give the instructions to NAO. The best distance is approximately 0.8m (usable range: 0.2 – 2.5m).

There are three tactile sensors in the head that allows different functions.

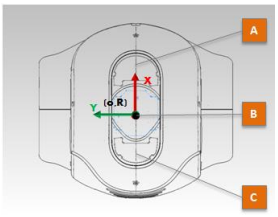

Figure 8. Tactile sensors of the head

Table 2. Sensors functions

Sensor Name	Type	Function
A	Front	Start the session. Restart a part.
B	Middle	Stop a part
C	Rear	End a part.

NOTE: before restarting a part, please stop it.

The motors allow the movement of the joints to form different poses controlling their motion speed and position.

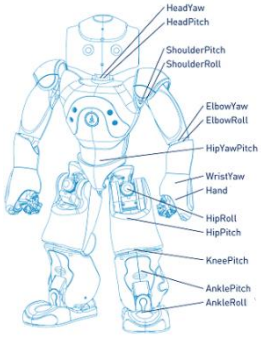

Figure 9. Motor joints

2.3 SOFTWARE

Python [38] is one of the programming language supported by NAO. Because of this language is the code that is below the main software tool of NAO, Choregraphe [39], we decided use it to develop the main program.

NAOqi [30] is the name of the main software that runs on the robot and controls it.

The NAOqi Framework is the programming framework used to program NAO.

The NAOqi executable which runs on the robot is a broker. When it starts, it loads a preferences file called autoload.ini that defines which libraries it should load. Each library contains one or more modules that use the broker to advertise their methods.

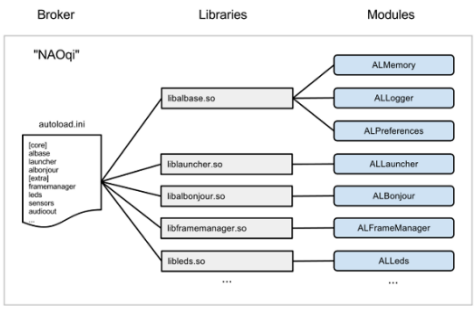

Figure 10. NAOqi Framework

The broker provides lookup services so that any module in the tree or across the network can find any method that has been advertised.

Loading modules forms a tree of methods attached to modules, and modules attached to a broker.

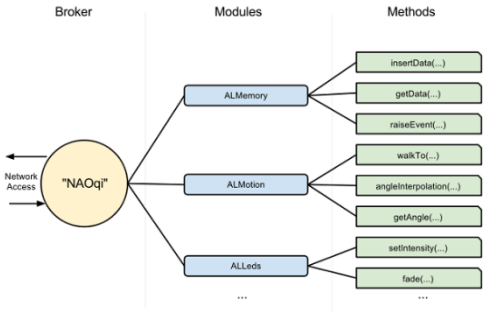

Figure 11. NAOqi libraries

Typically each Module is a class within a library. When the library is loaded from the autoload.ini, it will automatically instantiate the module class. Each module contains various methods.

2.3.1 NAO speech

To speak in an understandable and comprehensive way the text to speech library has been used as the principal module. It allows write the words you want NAO says. Changing the speed and the pitch parameters of the speech a natural oral communication is achieved.

2.3.2 NAO motion

The key point here is to use body language in this context as the principal means to induce mood. To move according the things NAO is saying or it is hearing in the mindfulness video a synchronized audio-movement method is needed. The different positive poses and movements based on [1] and the rhythm of the speech or the mindfulness video is achieved through the timeline pane of the Choregraphe application. It also allows to synchronize them. The Timeline panel is displayed when you double-click on a Timeline box.

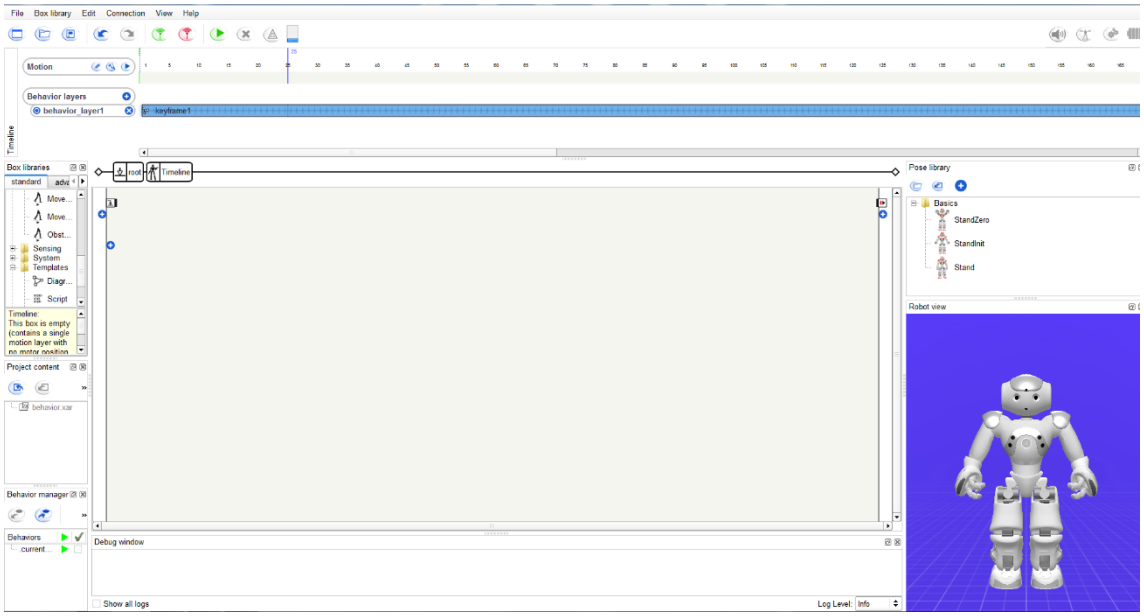

Figure 12. Timeline panel

It enables you to edit the Timeline of the box.

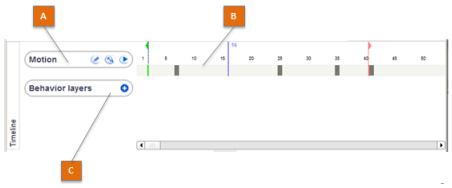

Figure 13. Timeline of the box

A Timeline enables you to easily synchronize boxes with movements, movements with each other and/or boxes with each other. It is constituted by:

- A Motion layer which contains movements.
- Optionally one or several behavior layers which contain flow diagrams NAO will execute in addition to its movements.

The whole Timeline is based on a time ruler. The time is represented on the Timeline by numbered Frames. Each Frame corresponds to a position of the robot and/or Flow diagrams to execute. The speed to move from a Frame to another is defined by the Frame rate of the Timeline.

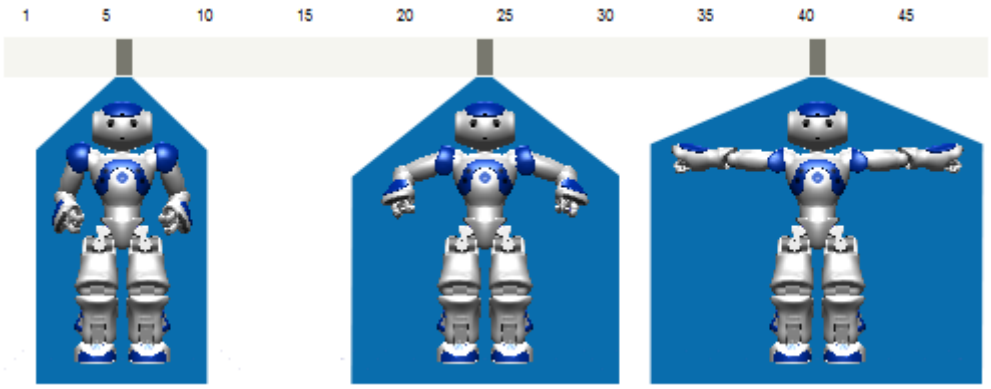

Figure 14. Postures in three different points of the timeline box.

Each body position can be done modifying the position of each joint selecting the correspondence part of the body in the simulated robot which appear in the timeline panel.

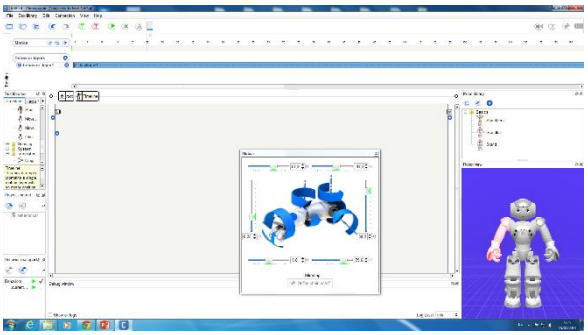

Figure 15. Creating a posture with the simulated robot.

Another possibility to create a new posture is manipulating and recording the position of the joints in the real robot. Both methods store joints positions in the key frame selected. You can select to record whole body or different parts of the body (head, arms and/or legs).

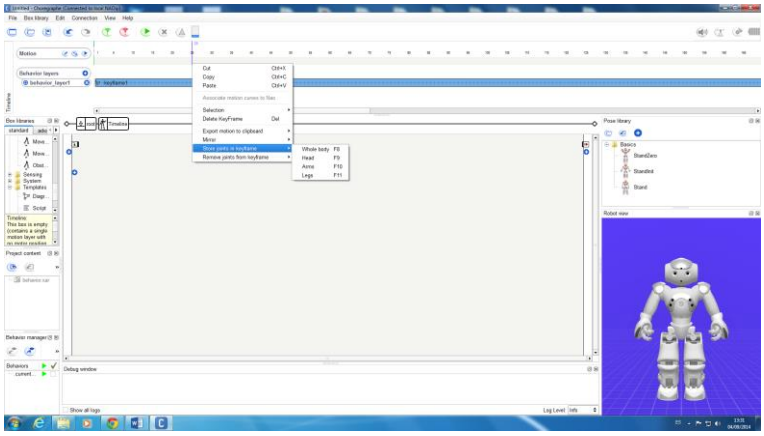

Figure 16. Recording a posture in a key point of the timeline.

2.3.3 Speech recognition

Speech recognition is used here because the robot requires manages the dialogue with the therapist.

There is a module in NAOqi that allows the speech recognition. Although theoretically it can recognize any word, in practice, there are a lot of words that it does not recognize very well. This module is done fundamentally to discriminate some words or short sentences of a concrete list to select a choice between different options. Both were supposed a problem to develop an adequate way to recognize the main instructions the therapist tells to NAO. On one hand, it is very difficult to NAO discriminates words when a continue speech is doing. Some words are very similar and this can confuse the recognition process. On the other hand, the recognition process changes depend on the distance between the person who is speaking and the robot. These two difficulties have been resolved in a practical way, with so many trial and error tries. These experiemnts are described in Chapter 3.

2.3.4 Positive mood

According to [1], positive mood can be expressed with positive corporal language implemented in the robot, see [25-26, 28-29, 31, 40, 46]. Table 2 resume these postures:

Table 3. Words of ANEW which appear in the therapeutic narrative of the mindfulness session

Part of the body	Position	Meaning
Head / body	Erect.	Pride, joy.
Body	Facing squarely to other people	Social stance

Arms	Raised and tilted slightly backward.	Happiness, surprise, pride.
Arms	Open, above the shoulders and head	Happiness, success, surprise.
Arms	Stretched out frontal or upward	Elated joy.
Arms	Crossed in front of chess	Happiness.
Arms / legs	Uncrossed and opened.	Open social posture.
Shoulders	Lifted.	Elated joy.
Forearms	Rotated outwards.	Social stance.
Elbows	Extended or slightly bent.	Joy.
Hands	Hand (s) in the heart (left breast)	Need to emphasize their truthful position.

Speed, pitch and volume of the voice contribute to transmit the speech information in a positive way too.

Despite the sentences NAO and the therapist says has been elaborated for the psychologists, we have wanted to know what words appear in the Spanish adaptation of the ANEW and what values have in the arousal, valence and dominance dimensions of the affective states for women (because of all the patients are women). The following table shows the results found:

Table 4. Words of ANEW which appear in the therapeutic narrative of the mindfulness session

Number	E-Word	S-Word	Val-Mn-Fem	Val-Sd-Fem	Aro-Mn-Fem	Aro-Sd-Fem	Dom-Mn-Fem	Dom-Sd-Fem
631	agreement	acuerdo	7,20	1,94	5,13	2,26	6,33	1,82
642	arm	brazo	5,24	1,10	4,80	1,72	5,61	1,58
205	heaven	cielo	7,54	1,62	4,59	2,56	4,56	2,85
457	trust	confianza	8,06	0,96	5,24	2,60	5,83	2,03
787	heart	corazón	6,79	1,79	6,06	1,98	4,99	2,23
13	aloof	distante	2,69	1,69	4,53	1,81	4,61	2,35
301	pain	dolor	1,47	1,41	6,40	2,61	2,53	2,17
155	exercise	ejercicio	5,71	1,99	6,26	2,04	6,33	1,91
414	strong	fuerte	6,17	1,74	5,84	2,10	5,13	2,56
805	imagine	imaginar	7,59	1,75	6,44	2,18	6,47	2,36
173	freedom	libertad	8,56	0,83	6,41	2,40	6,13	2,56
172	free	libre	8,20	1,33	6,09	2,88	7,03	1,83
751	fight	lucha	2,23	1,58	6,69	2,05	4,39	2,12
863	manner	manera	5,04	1,57	4,53	1,72	5,00	1,70
778	hand	mano	6,04	1,40	5,00	2,34	5,97	2,15
281	moment	momento	5,81	1,82	5,49	2,01	5,26	2,22
500	world	mundo	6,46	2,09	6,21	2,01	3,66	2,13
836	knot	nudo	4,07	1,61	4,84	1,92	5,31	1,79
327	pride	orgullo	5,06	2,29	5,91	1,78	5,33	1,88
323	power	poder	5,91	1,96	6,14	1,87	5,80	2,52
967	safe	seguro	7,46	2,00	4,33	2,46	7,07	2,08
132	dream	sueño	6,61	2,18	3,63	2,55	3,99	2,50
592	fear	temor	1,93	1,03	6,83	1,75	2,79	1,78
439	time	tiempo	5,34	2,26	5,56	2,03	3,60	2,31
258	life	vida	8,09	1,57	6,84	2,15	5,37	2,25

3 EXPERIMENTS

3.1 EXPERIMENTS ABOUT THE SYSTEM PERFORMANCE

The mindfulness session has three main parts. The first, when the therapist presents NAO and it introduces the main aspects of the mindfulness video and launches it. The second, when the video is playing and NAO moves according to the instructions of the video. And the third, in which NAO waves off. Each part has been tested in different ways described in the following sections.

More information is provided in Annex I.

3.1.1 BEHAVIORS

The behaviours have been developed in Choregraphe. Each part of the mindfulness session has a behavior developed here. All the parts must allow start it, stop it, and finish it because an unexpected problem could happen during the session. That is why all the parts contain the tactile head box to manage these possibilities.

The first part has the name Introduction. The first level is shown in the Figure 17.

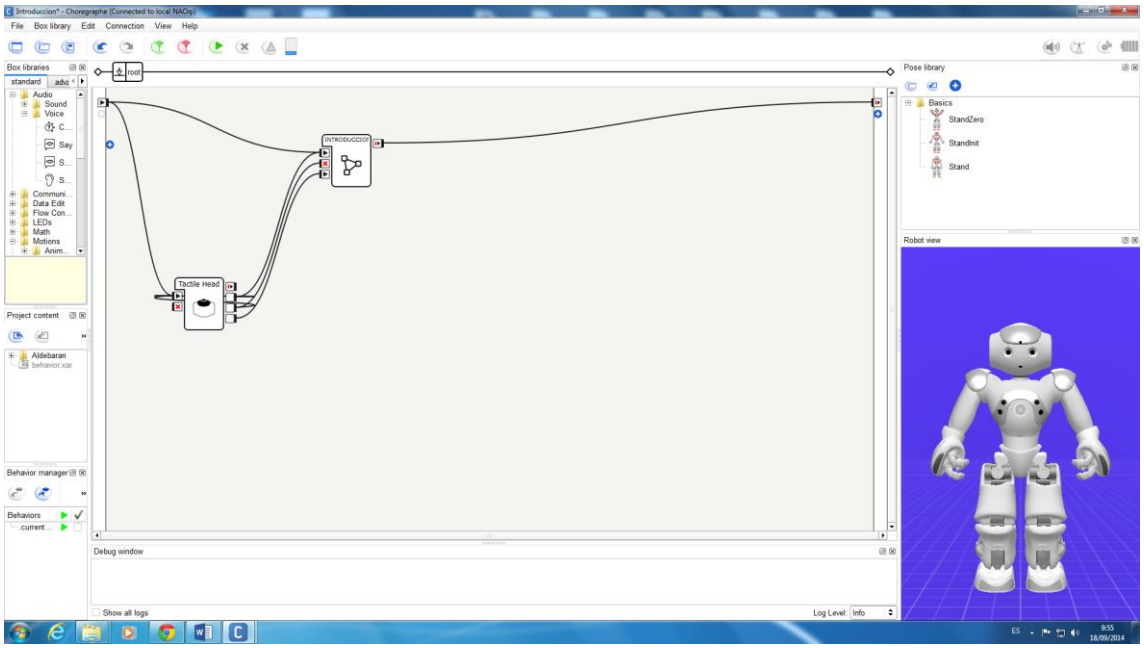

Figure 17. Introduction behavior (First level)

As there are two times in this part in which the therapist talks to NAO and it answers her, the are two parts in the behavior (Figure 18). In part 1, NAO gets up, listens to the therapist and it speaks with her (Figure 19). In part 2, NAO listens to the therapist for recognize the first sentence, since here, it does movements showing curiosity and finally, it recognizes the end of the part the therapist says for answers her and introduces the video (Figure 20).

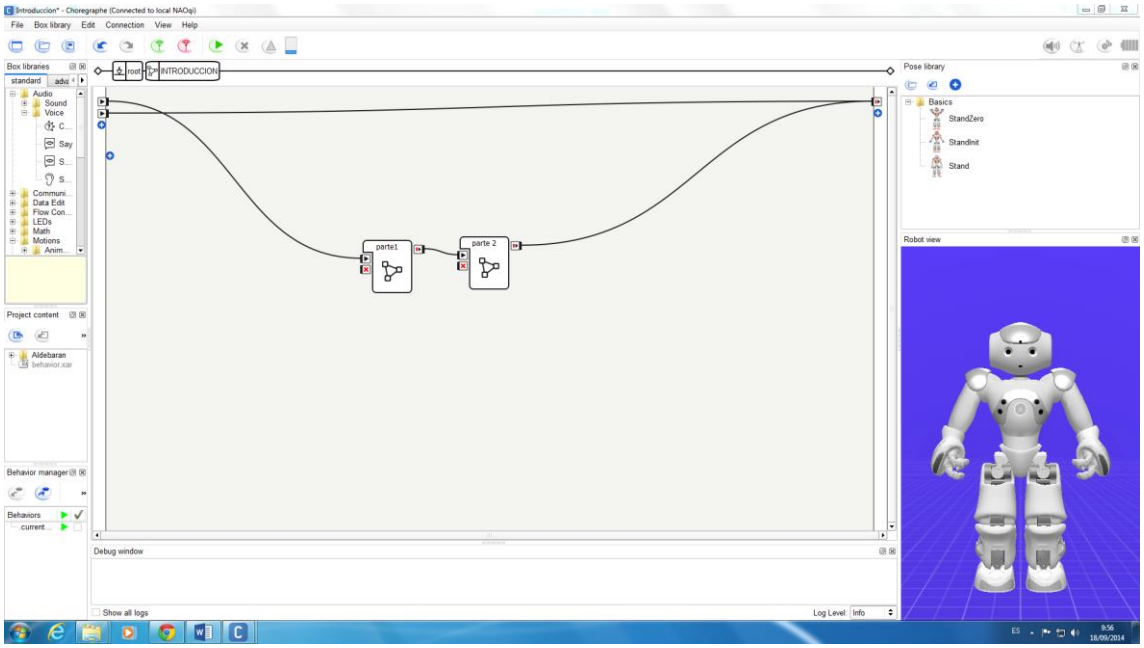

Figure 18. Introduction behavior (Second level)

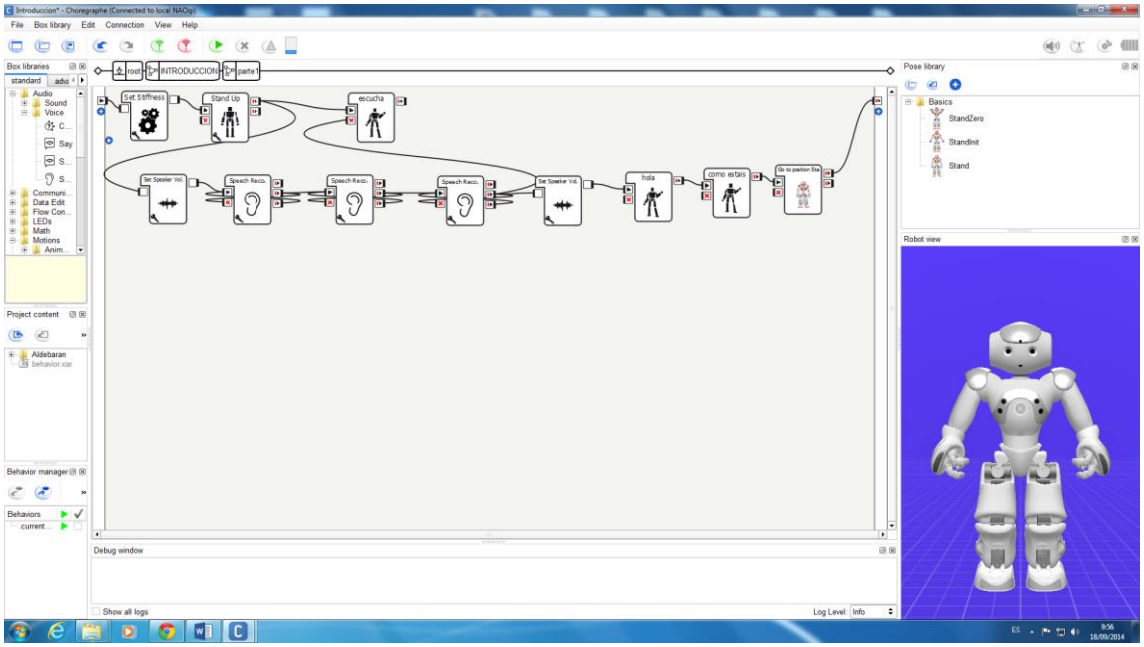

Figure 19. Introduction behavior (Part 1)

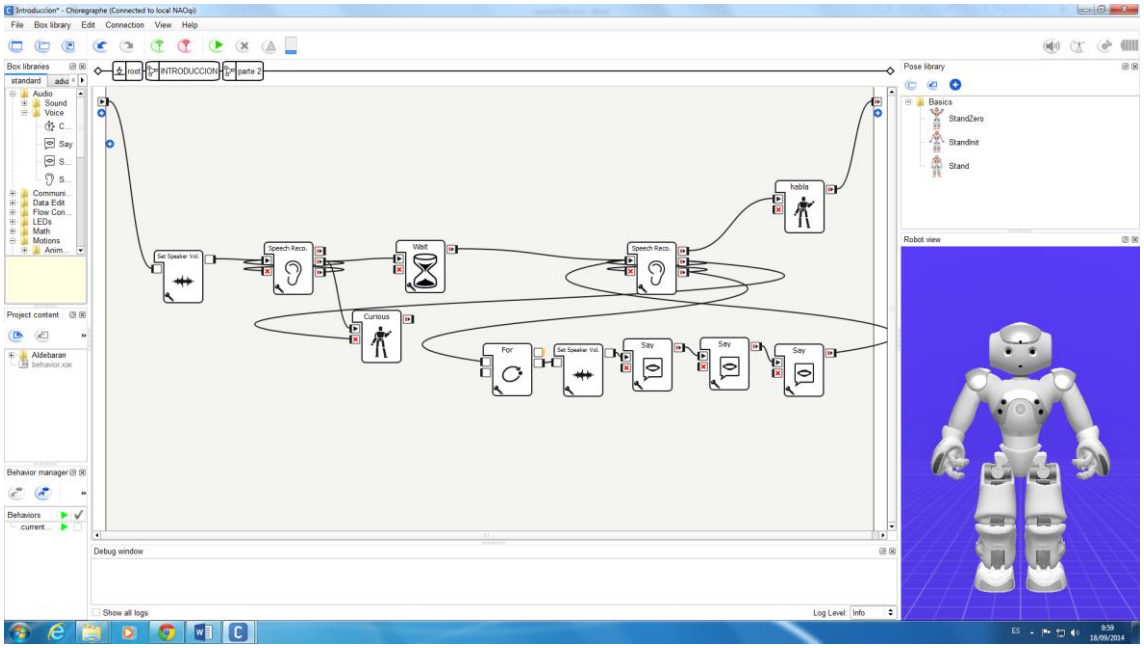

Figure 20. Introduction behavior (Part 2).

In the video behavior, NAO turns to sit down in front of the video. Before it must do the movements during the video proposed by the therapists, NAO gets up and moves for looking at the patients (Figures 21 and 22).

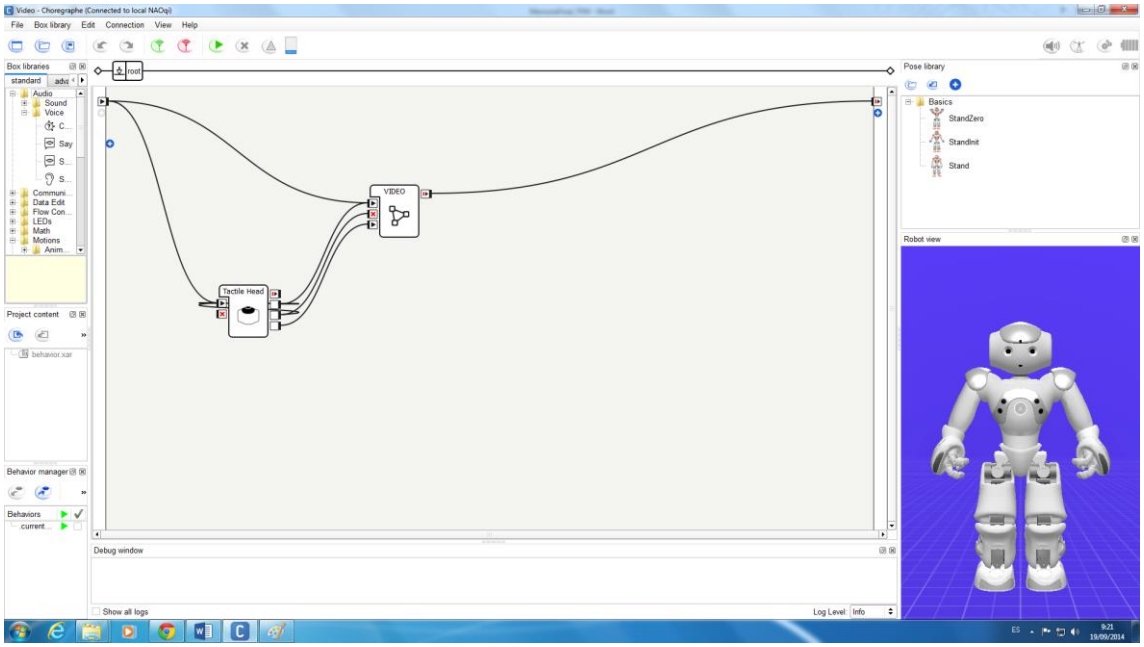

Figure 21. Video behavior (First level)

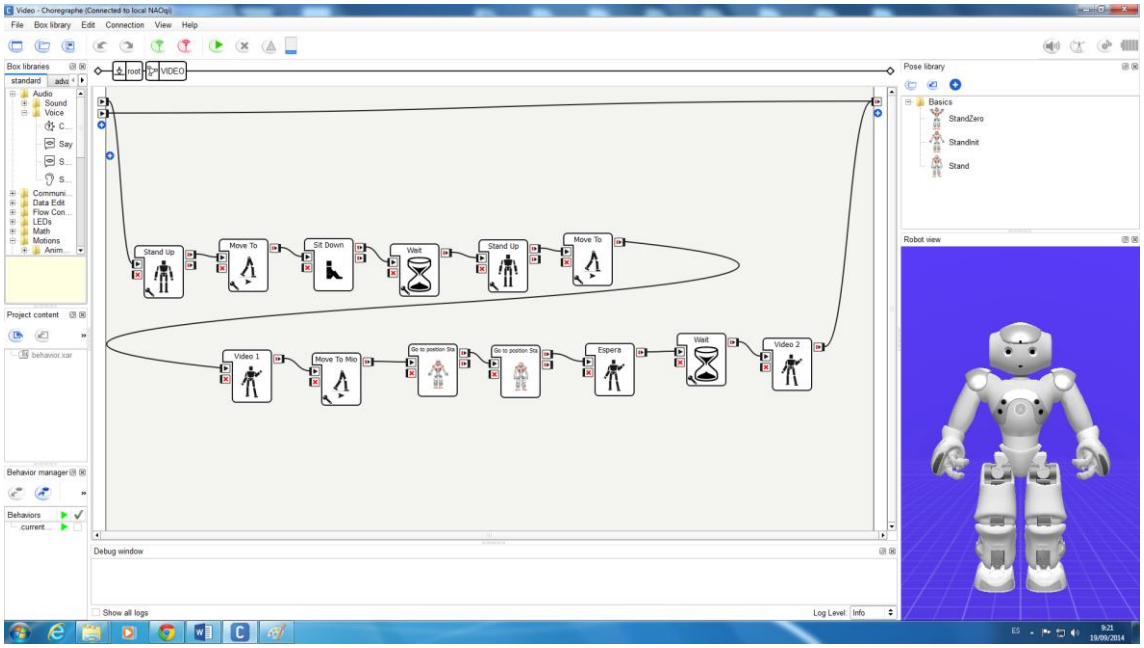

Figure 22. Video behavior (Second level)

Finally, NAO waves off in the third behavior (Figures 23-25).

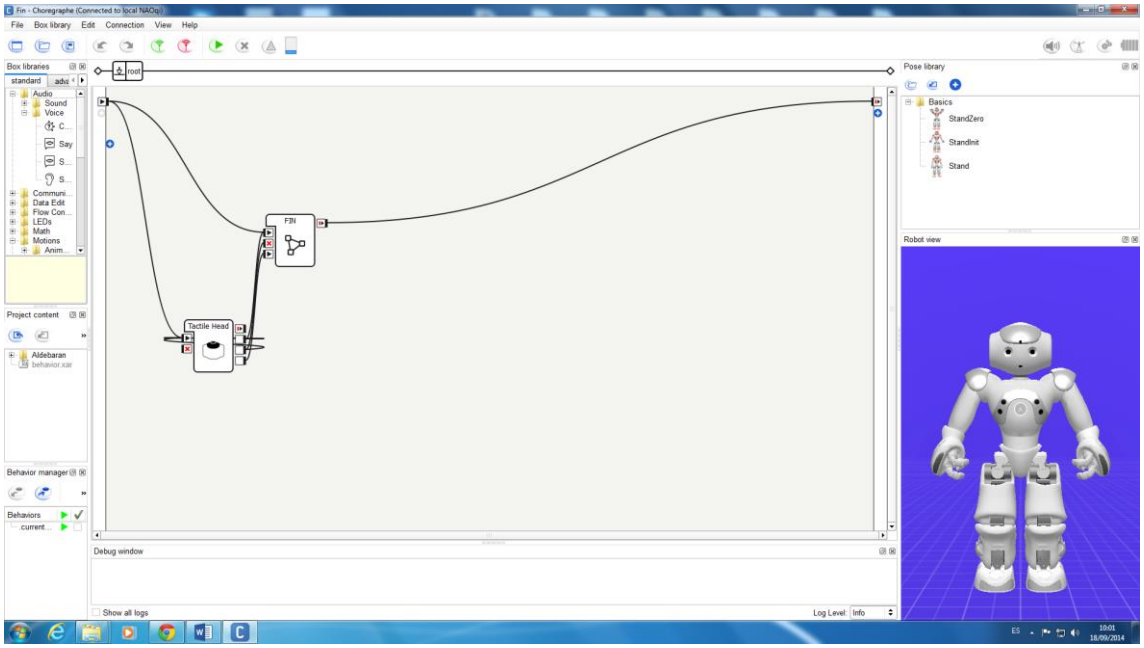

Figure 23. Third behavior (First level).

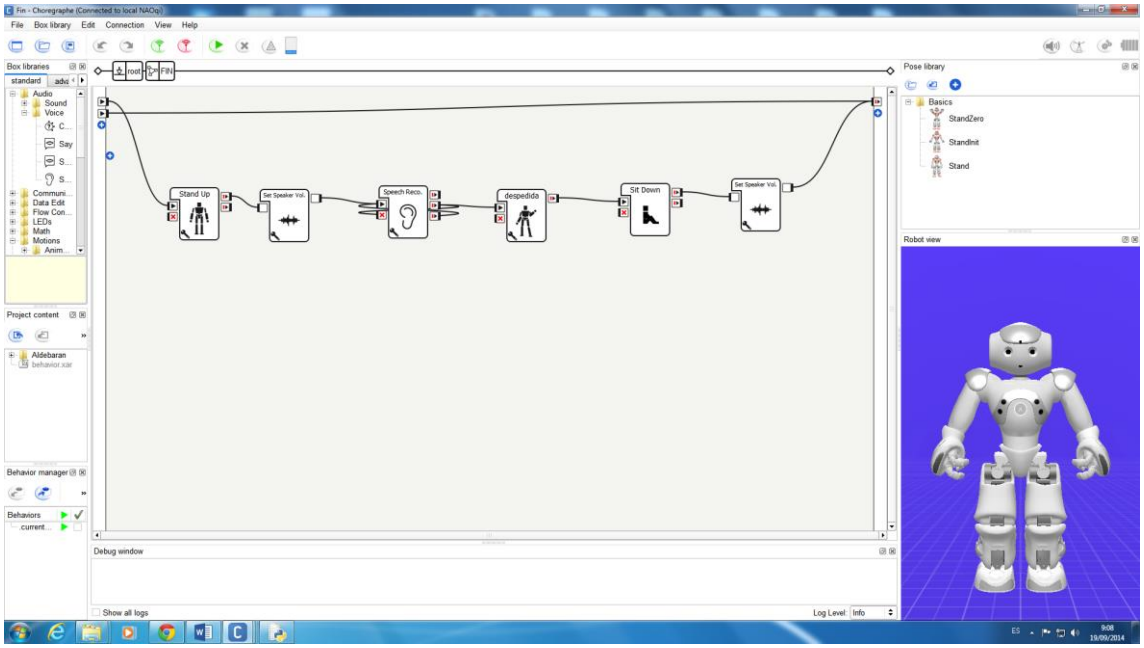

Figure 24. Third behavior (Second level)

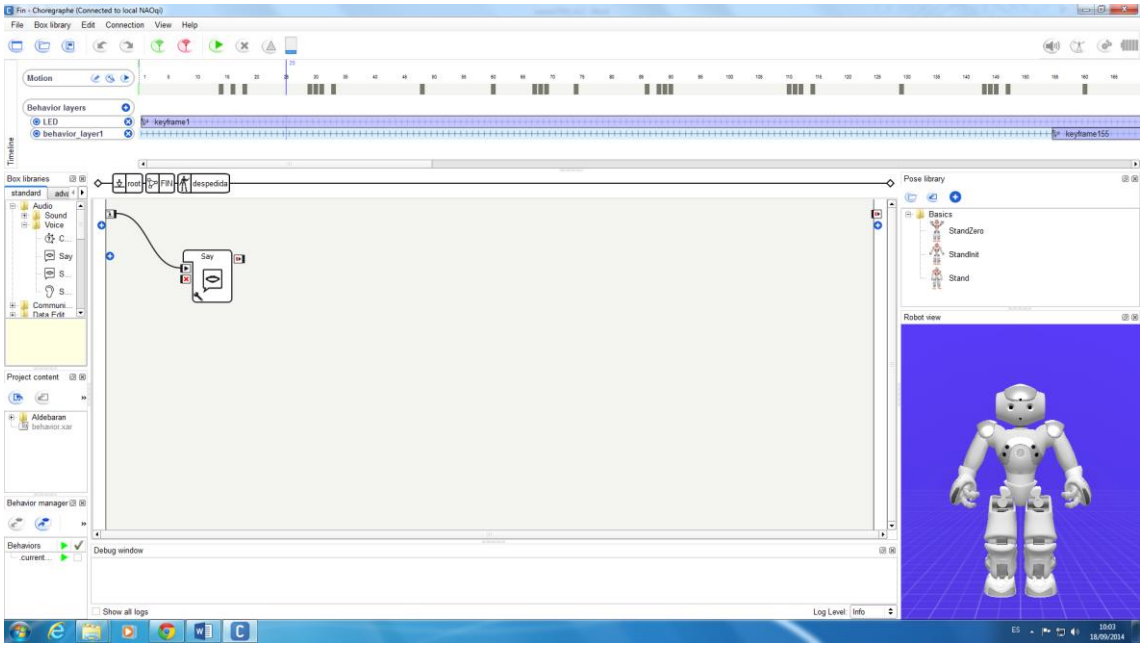

Figure 25. Third behavior (Wave off)

To manage these different behaviours and to launch the mindfulness video, a python script was done (Figure 26).

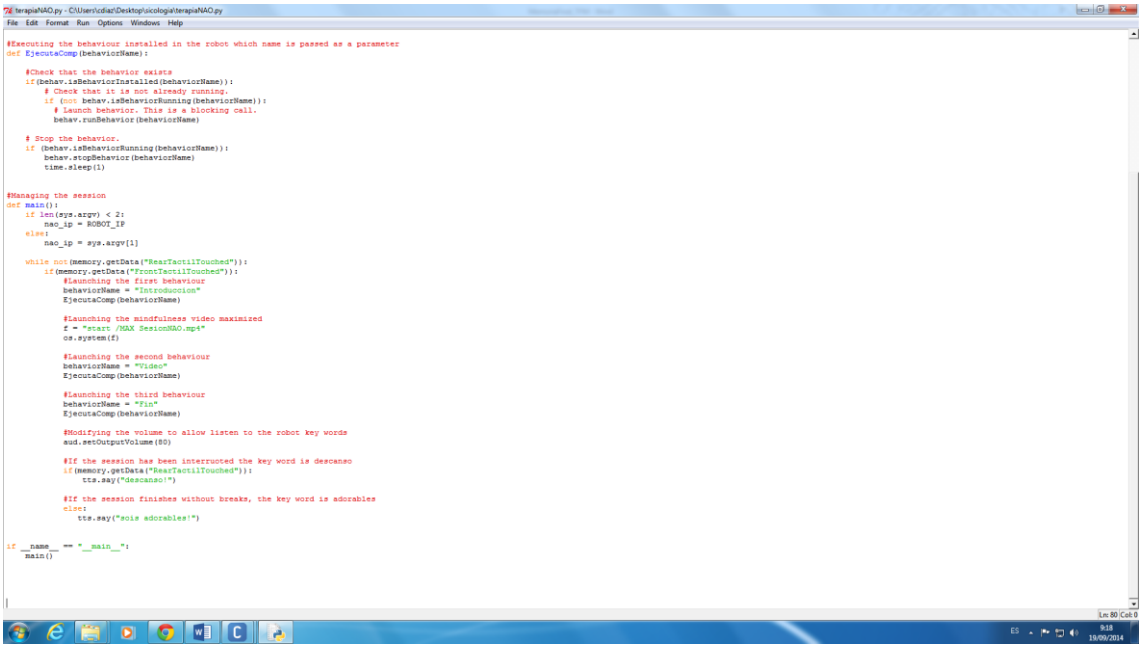

Figure 26. Python script

PYTHON CODE

```
"""
To manage the midfulness session
"""

#Importing the libraries
import os
import sys
import time
from naoqi import ALProxy

#Defining the IP address of the used robot
ROBOT_IP = "192.168.1.4"

#Creating proxys to the needed naoqui modules
tts = ALProxy("ALTextToSpeech",ROBOT_IP,9559)
aud = ALProxy("ALAudioDevice",ROBOT_IP,9559)
memory = ALProxy("ALMemory", ROBOT_IP, 9559)
behav = ALProxy("ALBehaviorManager", ROBOT_IP, 9559)
#asr = ALProxy("ALSpeechRecognition",ROBOT_IP,9559)

#Executing the behaviour installed in the robot which name is passed as a parameter
def EjecutaComp(behaviorName):

    #Check that the behavior exists
    if(behav.isBehaviorInstalled(behaviorName)):
        # Check that it is not already running.
        if (not behav.isBehaviorRunning(behaviorName)):
          # Launch behavior. This is a blocking call.
          behav.runBehavior(behaviorName)

    # Stop the behavior.
    if (behav.isBehaviorRunning(behaviorName)):
        behav.stopBehavior(behaviorName)
        time.sleep(1)

#Managing the session
def main():
    if len(sys.argv) < 2:
        nao_ip = ROBOT_IP
    else:
        nao_ip = sys.argv[1]

    while not(memory.getData("RearTactilTouched")):
        if(memory.getData("FrontTactilTouched")):
```

```
        #Launching the first behaviour
        behaviorName = "Introduccion"
        EjecutaComp(behaviorName)

        #Launching the mindfulness video maximized
        f = "start /MAX SesionNAO.mp4"
        os.system(f)

        #Launching the second behaviour
        behaviorName = "Video"
        EjecutaComp(behaviorName)

        #Launching the third behaviour
        behaviorName = "Fin"
        EjecutaComp(behaviorName)

        #Modifying the volume to allow listen to the robot key words
        aud.setOutputVolume(80)

        #If the session has been interruoted the key word is descanso
        if(memory.getData("RearTactilTouched")):
            tts.say("descanso!")

        #If the session finishes without breaks, the key word is adorables
        else:
            tts.say("sois adorables!")


if __name__ == "__main__":
    main()
```

3.1.2 SPEECH SYNTHESIS

Changing the speed and the voice shaping parameters of the speech a natural oral communication was achieved. Another feature that modifies the speech is the place of different pauses. Results are shown below:

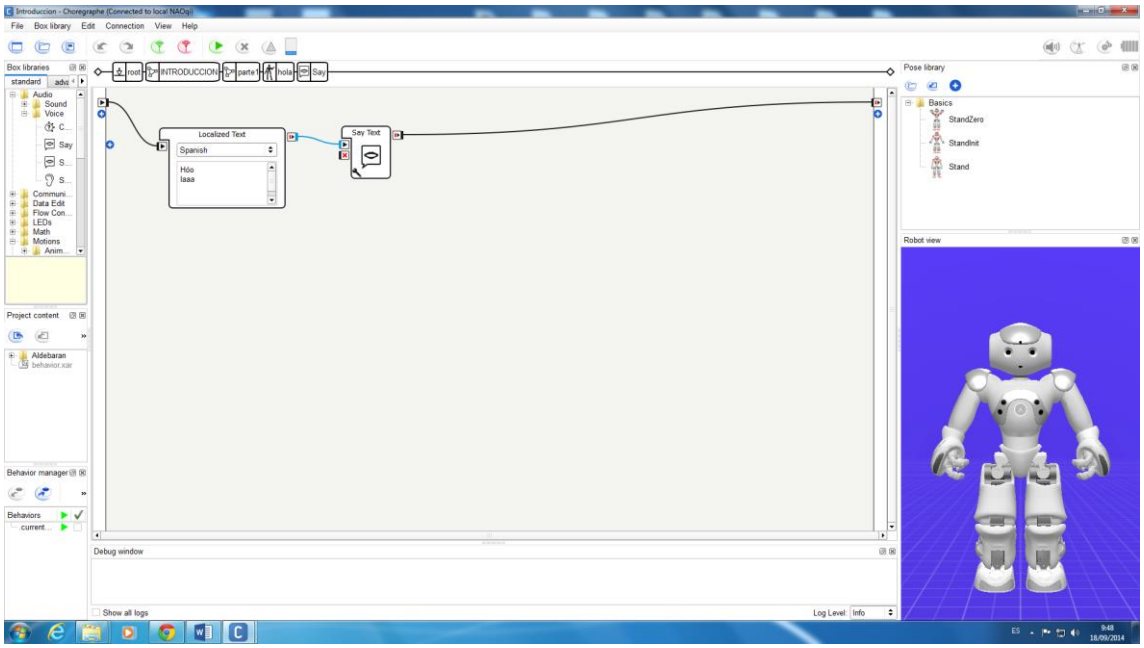

Figure 27. Speaking

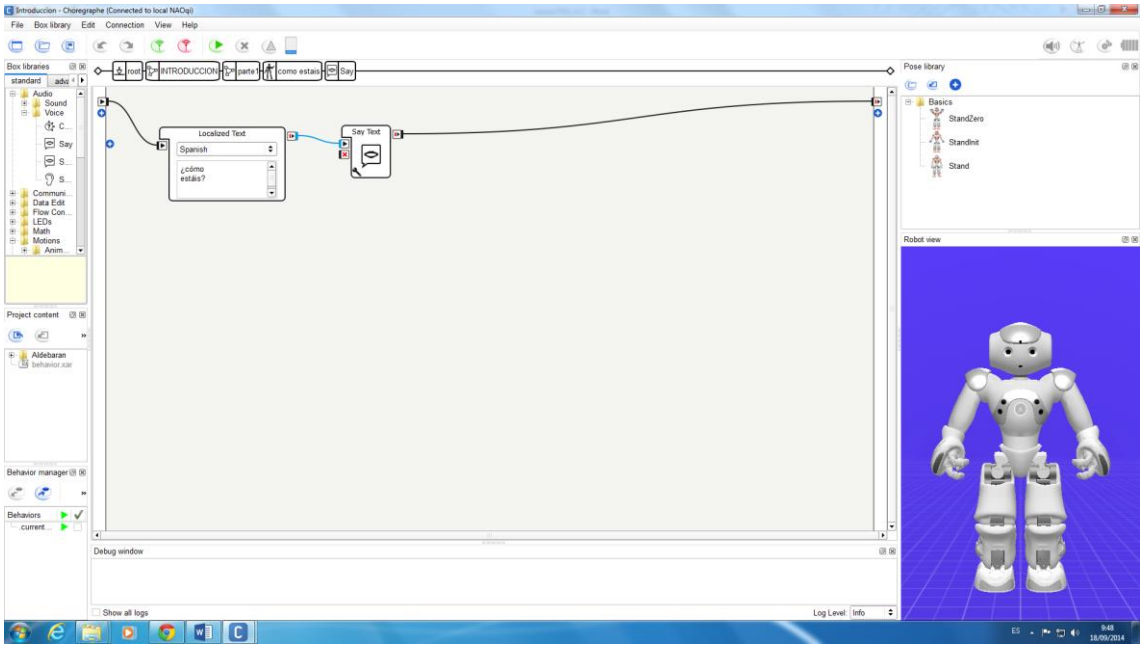

Figure 28. Speaking (Introduction, part 1)

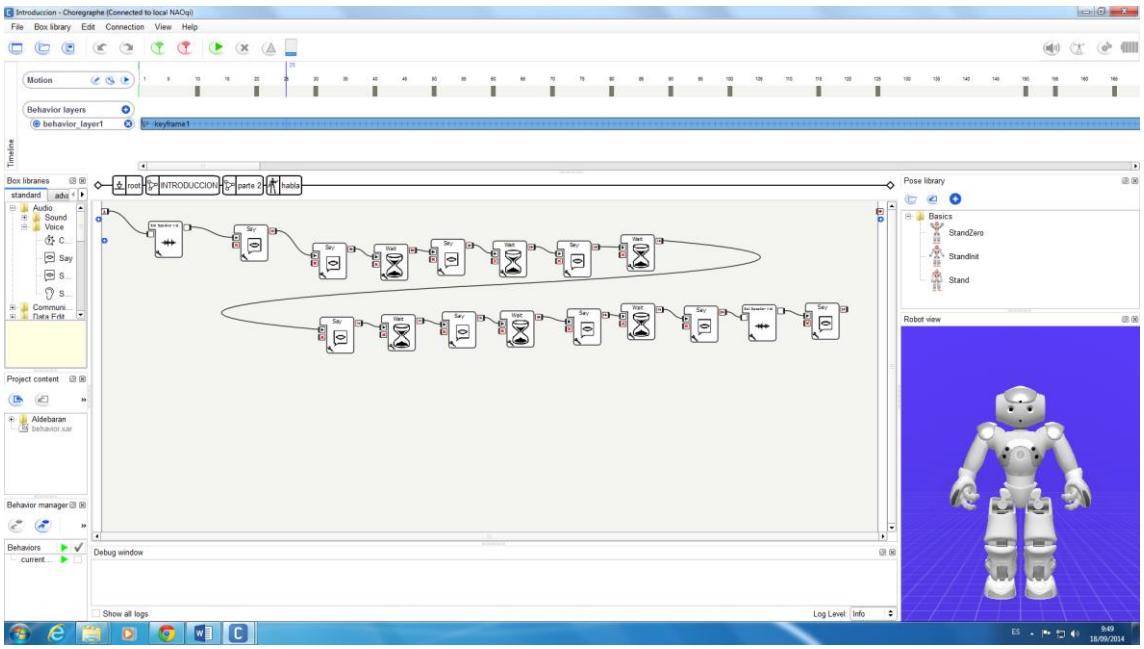

Figure 29. (Introduction, part 2)

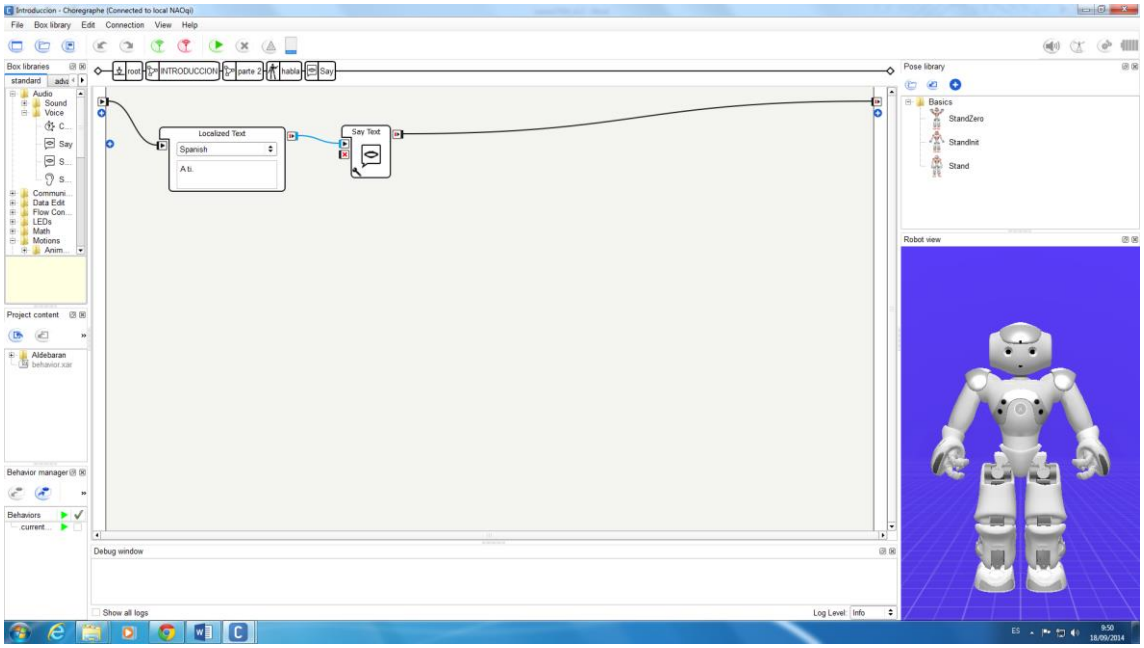

Figure 30. Speaking (Intoduction, part 2).

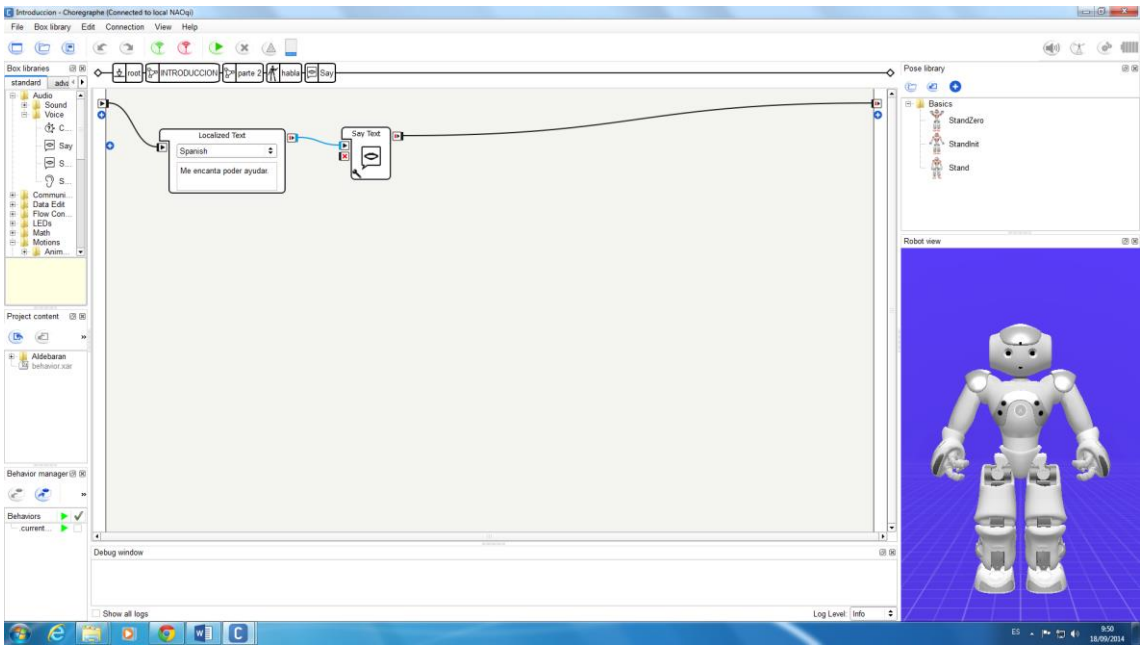

Figure 31. Speaking (Introduction, part 2, continuation).

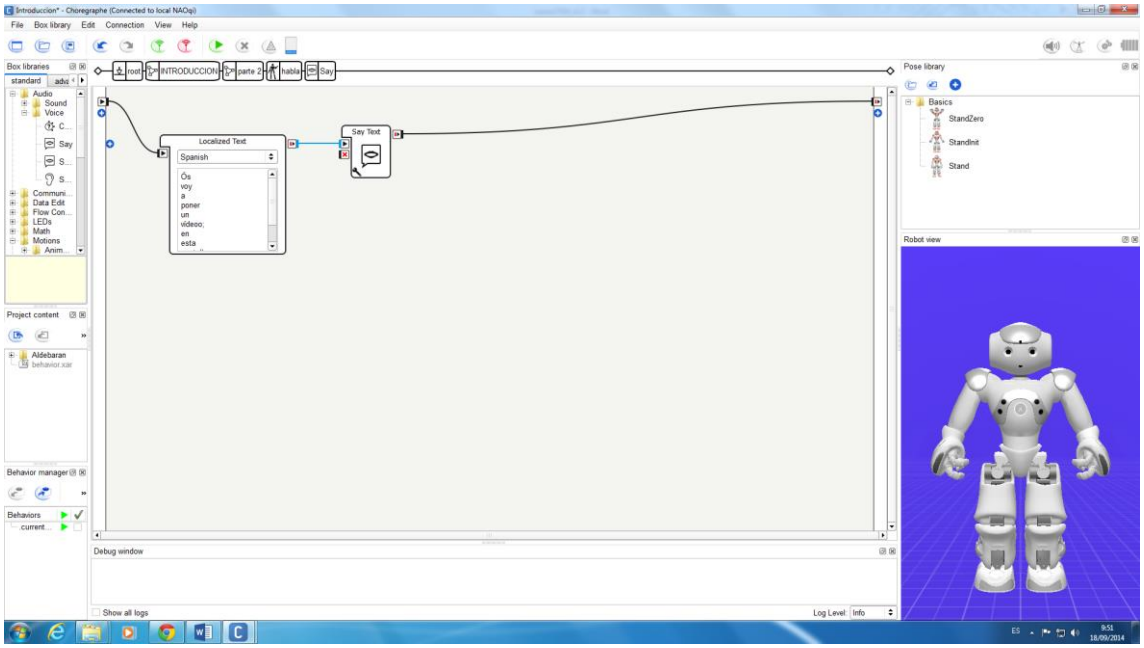

Figure 32. (Introduction, part 2, continuation)

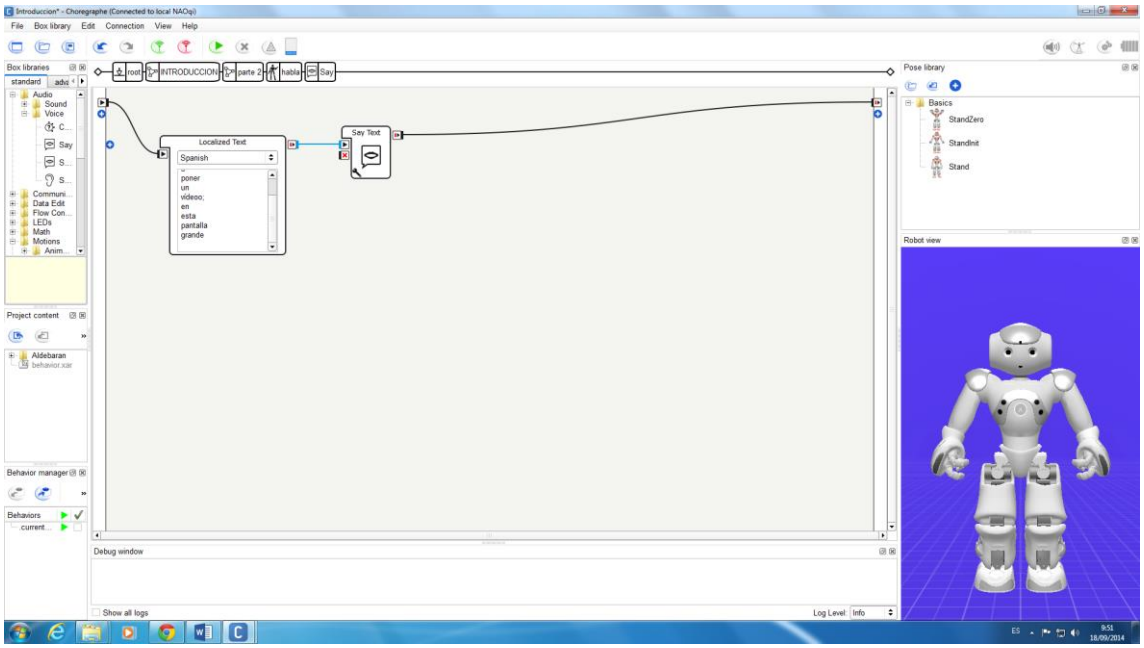

Figure 33. (Introduction, part 2, continuation)

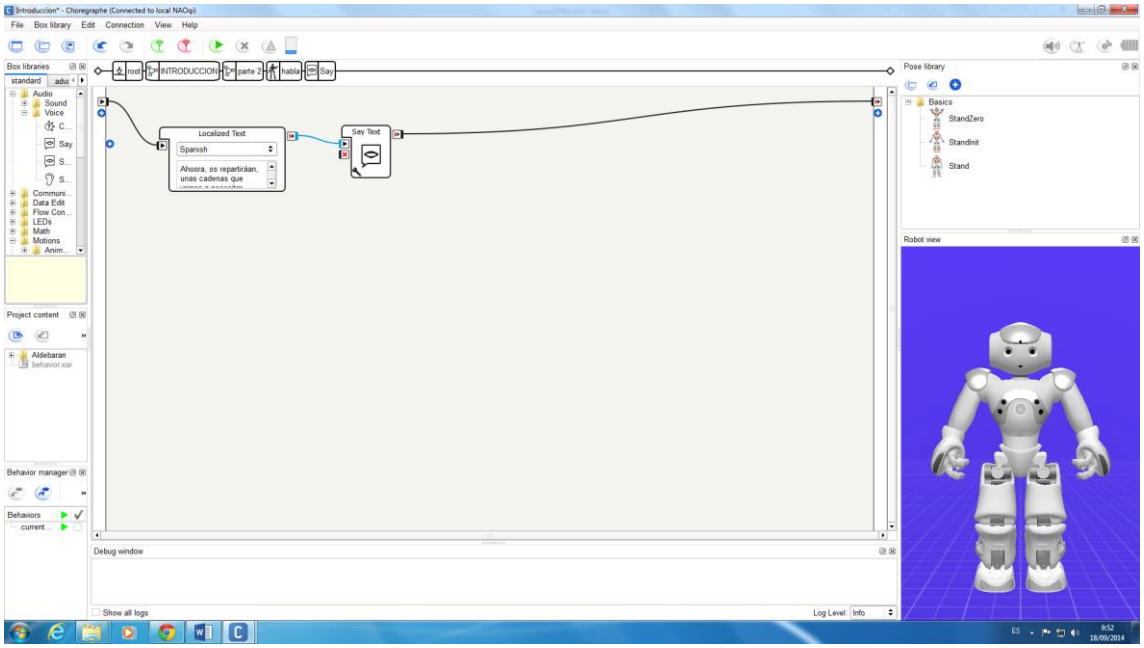

Figure 34. (Introduction, part 2, continuation)

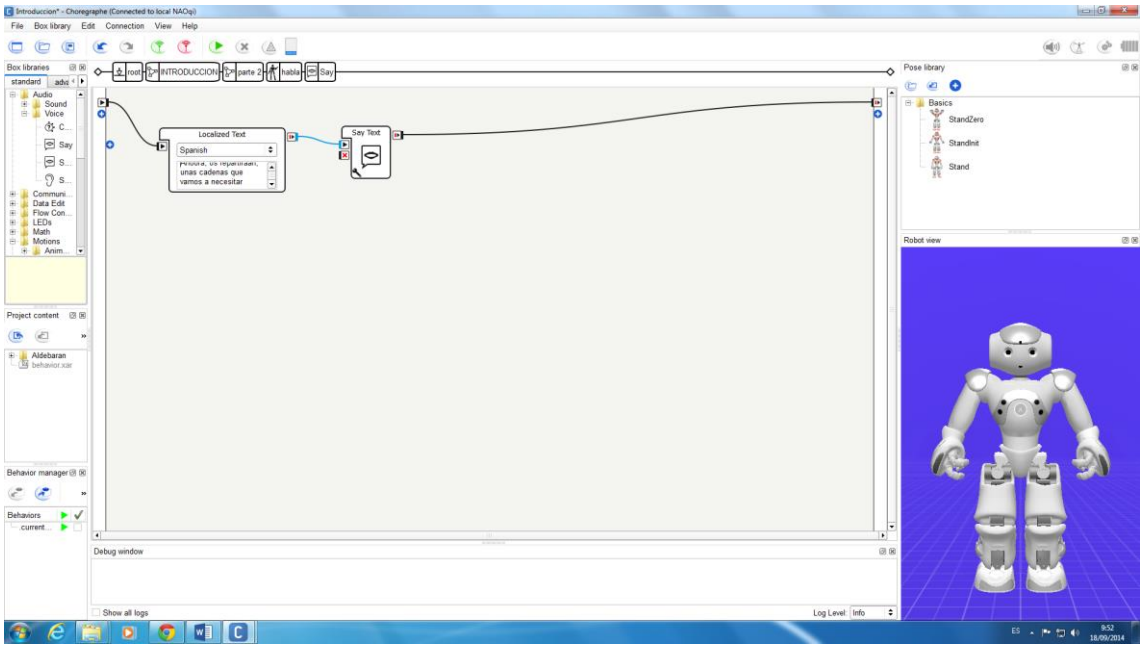

Figure 35. (Introduction, part 2, continuation)

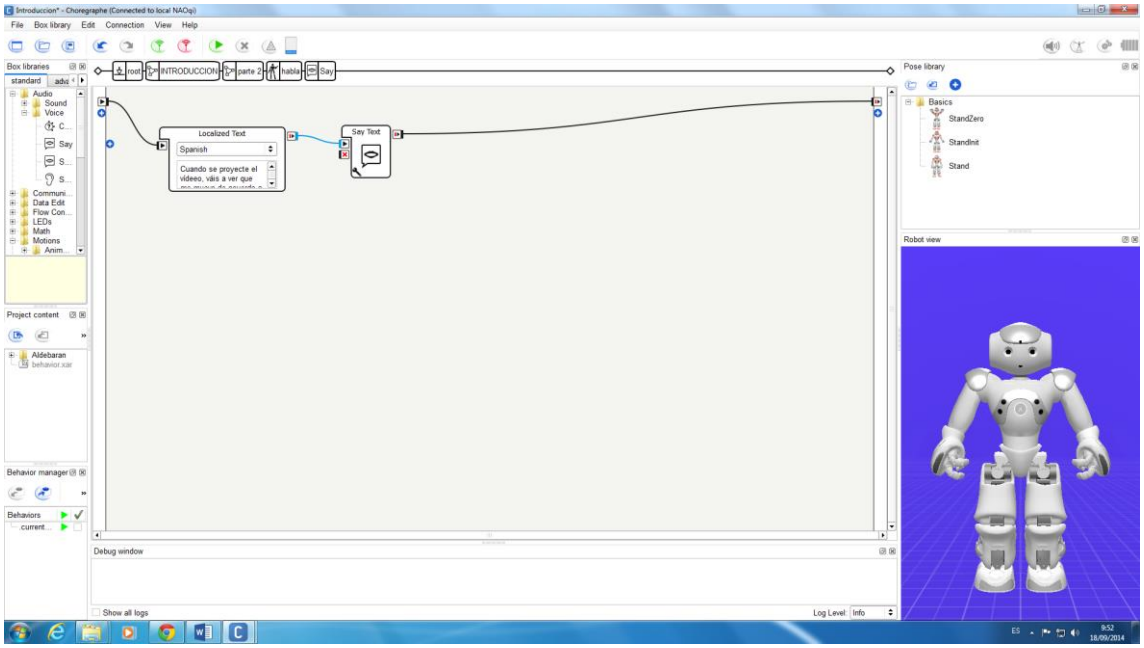

Figure 36. (Introduction, part 2, continuation)

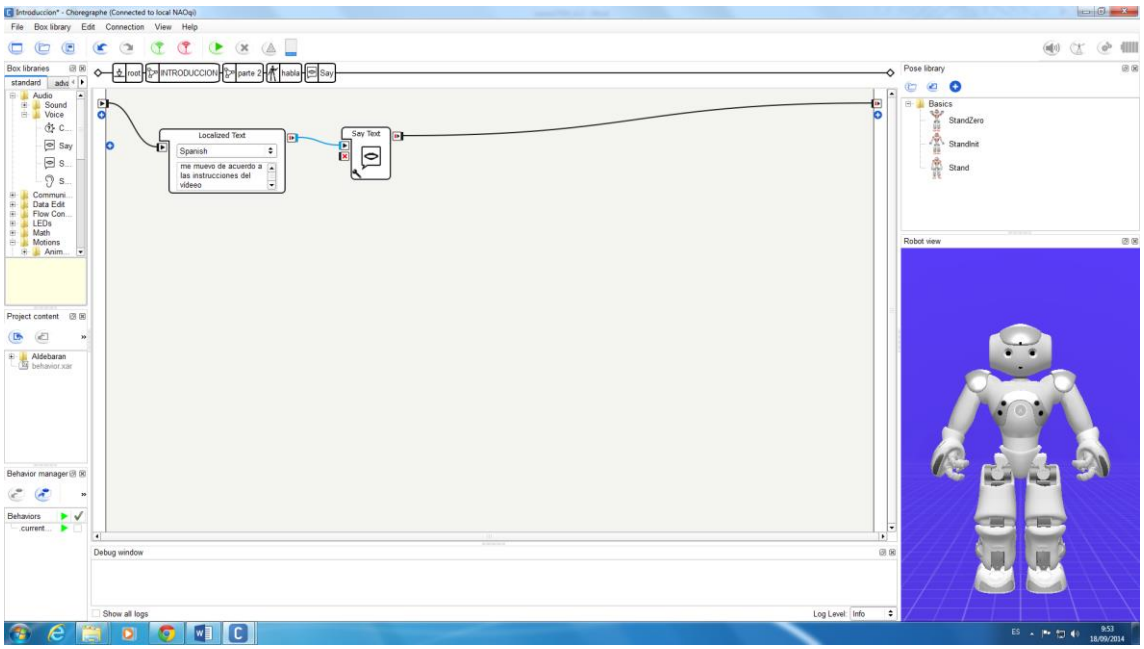

Figure 37. (Introduction, part 2, continuation)

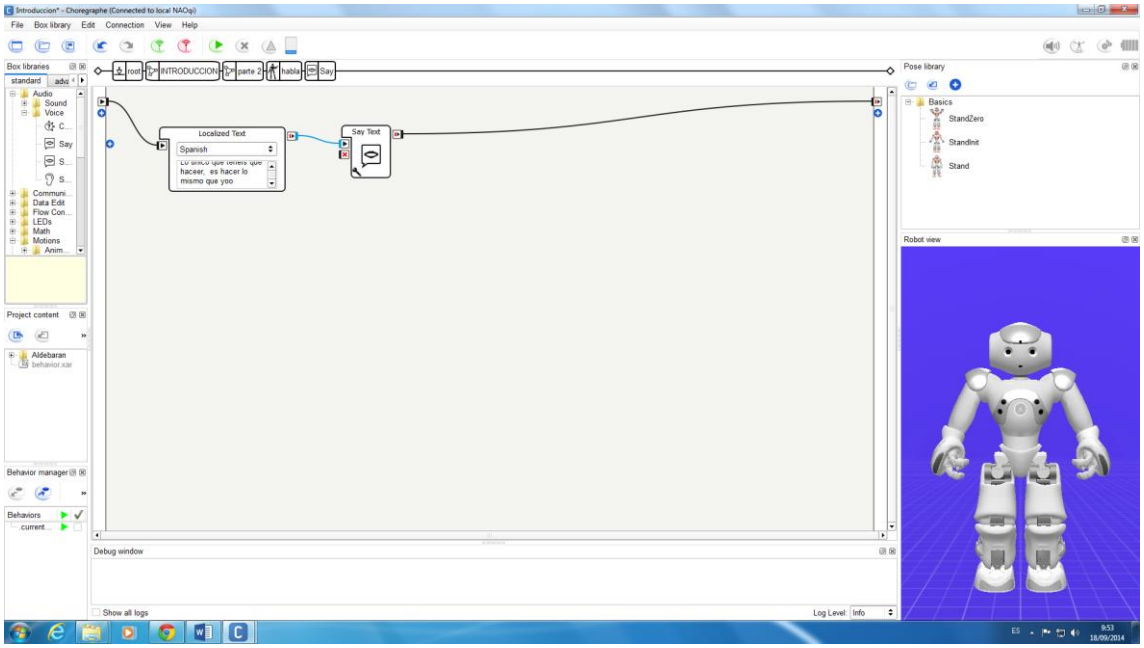

Figure 38. (Introduction, part 2, continuation)

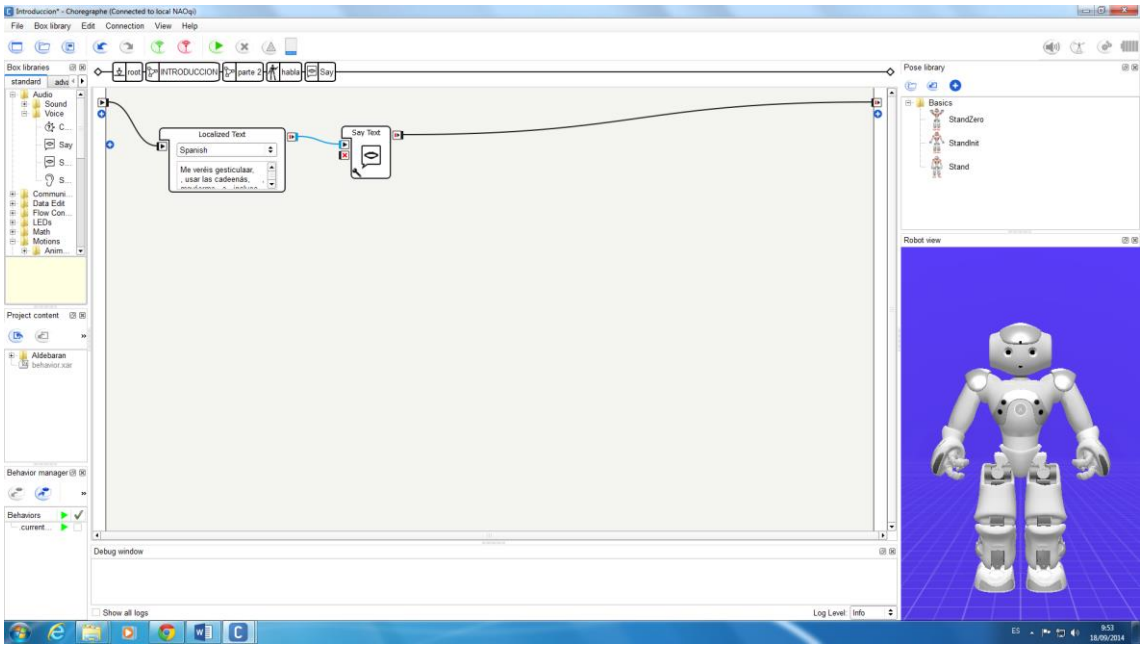

Figure 39. (Introduction, part 2, V)

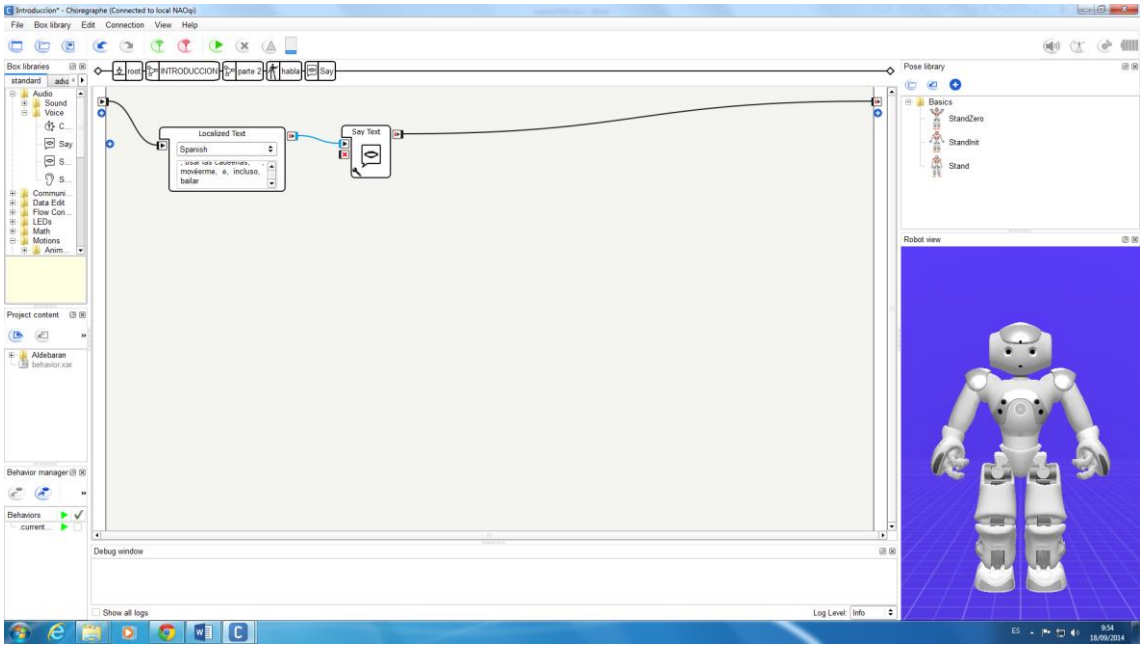

Figure 40. (Introduction, part 2, continuation)

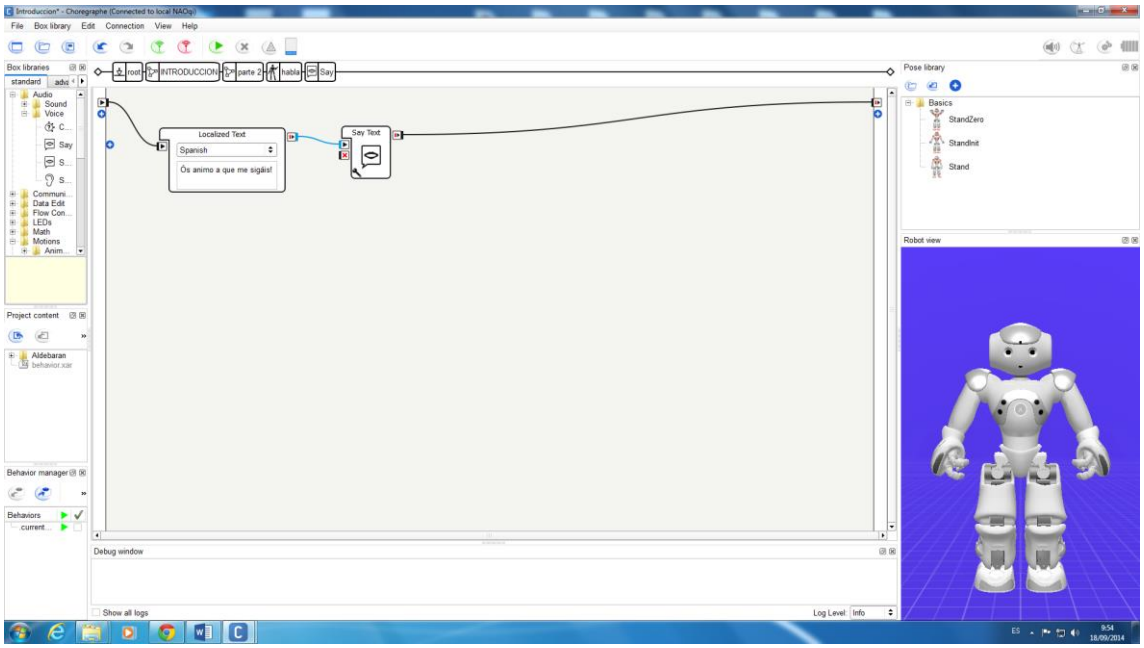

Figure 41. (Introduction, part 2, continuation)

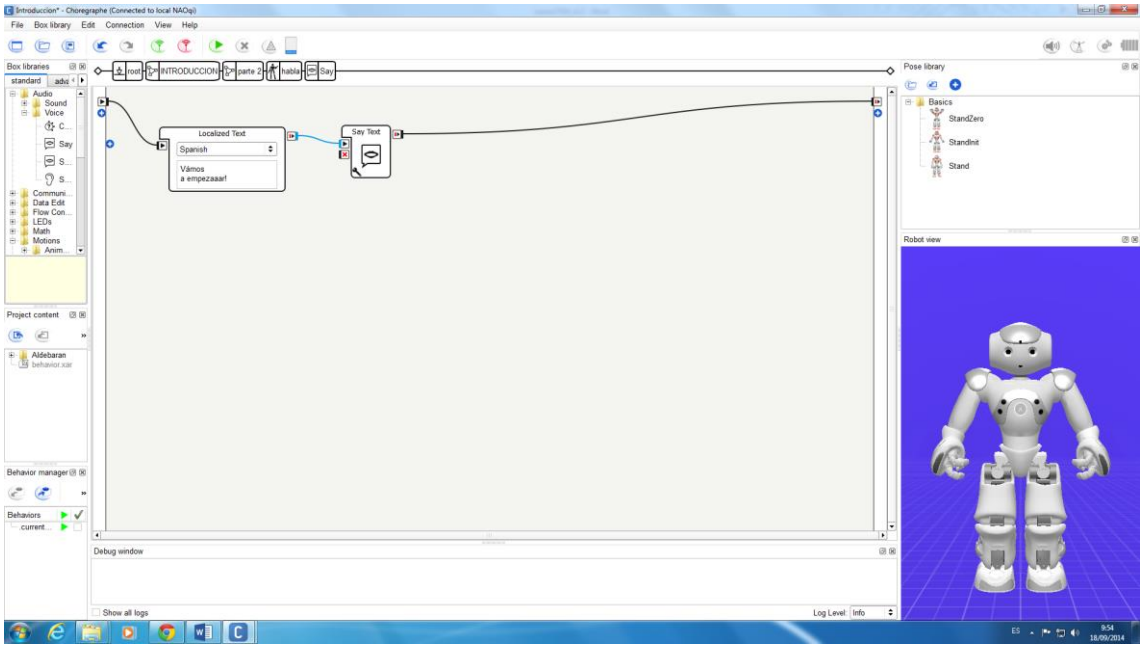

Figure 42. (Introduction, part 2, continuation)

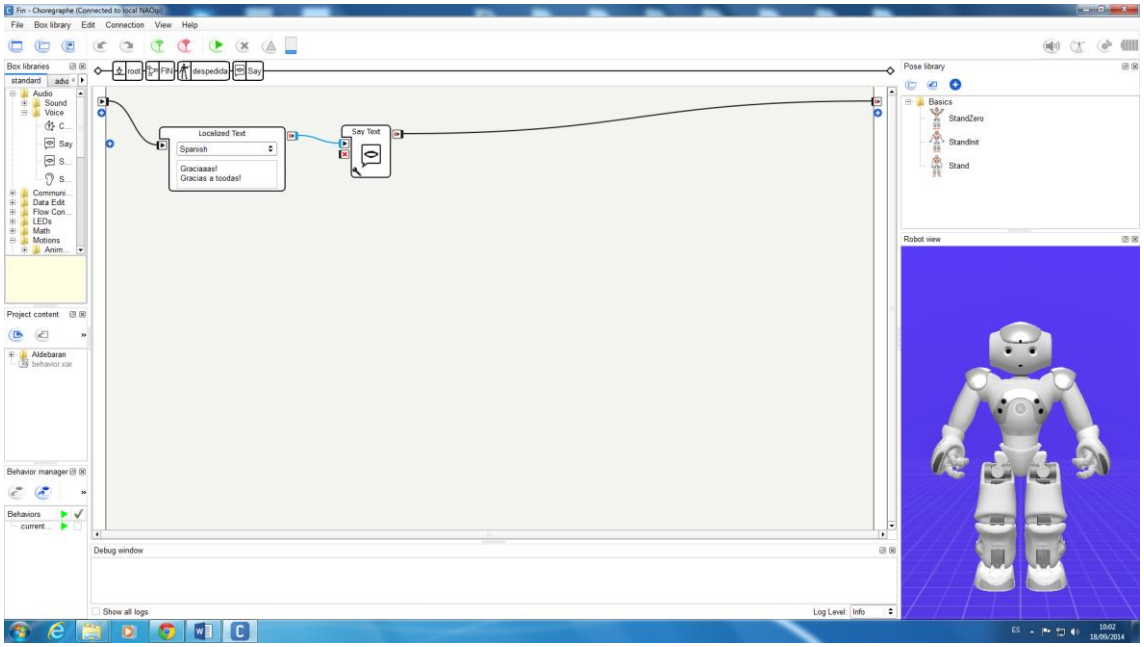

Figure 43. End

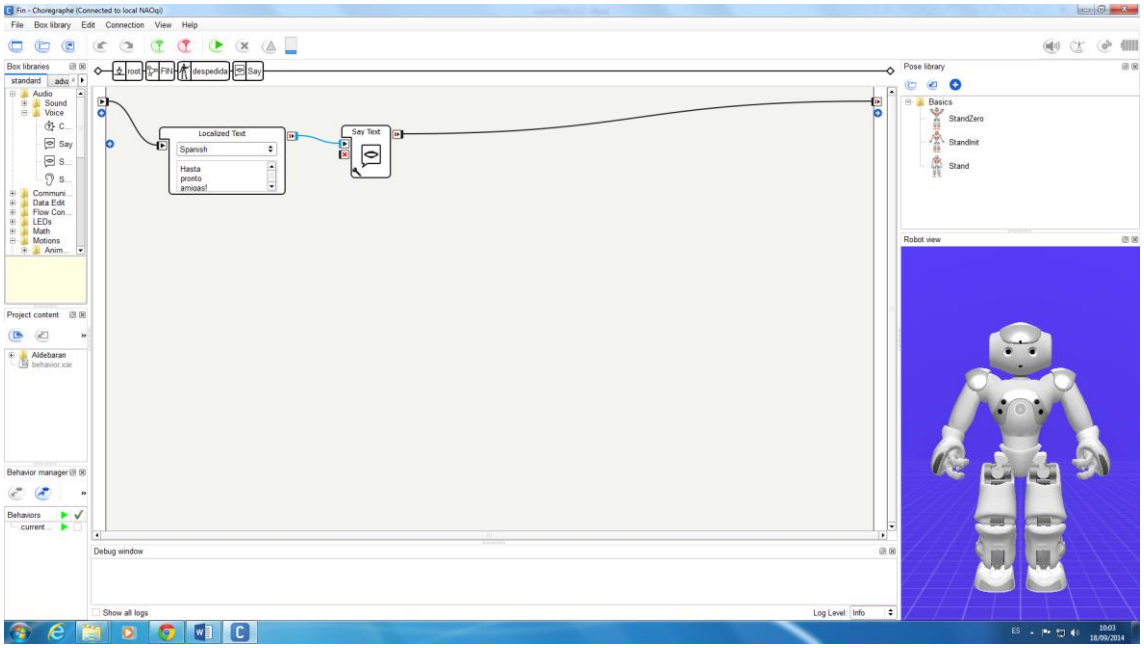

Figure 44. End (continuation)

3.1.3 SPEECH RECOGNITION

I decided to run tests at different distances with almost of the words that NAO should hear from the therapist to choose the best recognized words (from 0.2m to 3m in 0.2m each step). Each word has been tested ten times for each distance. The experiments were done in the Robotics Intelligence Laboratory. It allows ambient noise in a natural way (not provided explicitly) to ensure the availability of the recognition process outwards. The table below shows the results with the 15 best average measures highlighted:

Table 5. Recognition words tests

Word or sentence	Recognition at 0.2m (%)	Recognition at 0.4m (%)	Recognition at 0.6m (%)	Recognition at 0.8m (%)	Recognition at 1m (%)	Recognition at 1.2m (%)	Recognition at 1.4m (%)	Recognition at 1.6m (%)
Hoy	60	60	20	60	40	40	40	60
Vamos	80	100	60	80	60	20	40	40
Tener	40	100	80	80	80	60	80	60
Ayuda	60	40	20	100	80	80	40	0
Especial	100	100	100	60	60	40	80	0
Presento	70	40	70	60	30	50	50	40
Nao	40	20	0	40	0	40	20	20
Va a ser	100	100	80	100	60	60	40	20
coterapeuta	30	30	10	10	70	0	10	10
Hola	90	90	80	70	40	70	10	50
Hola Nao	20	60	60	30	10	20	20	20
Ayudar	80	80	100	40	40	0	40	20
Hacer	80	100	80	80	80	80	100	60
Ejercicio	40	40	40	60	20	40	20	20
Servir	100	100	80	40	60	20	60	60
Reflexionar	100	100	80	80	80	60	20	60
Dolor	20	40	40	20	40	20	0	0
Impide	40	60	60	20	80	60	40	60
Cosas	100	100	80	80	40	0	20	0
Queremos	0	0	0	0	0	20	0	0

Estrategias	100	80	60	80	20	20	20	0
A pesar	100	100	100	80	100	100	100	80
Ahora	60	100	100	100	100	60	80	60
Le dejo	80	100	40	40	0	0	0	0
Que siga	80	100	100	100	100	60	80	60
Gracias	90	90	80	30	70	70	70	70
Muchas gracias	40	40	60	40	70	40	30	20
Gracias Nao	60	80	20	30	50	60	40	40
Muchas gracias Nao	60	20	0	0	0	0	0	0

Table 6. Recognition words tests (continuation)

Word or setence	**Recognition at 1.8m (%)**	**Recognition at 2m (%)**	**Recognition at 2.2m (%)**	**Recognition at 2.4m (%)**	**Recognition at 2.6m (%)**	**Recognition at 2.8m (%)**	**Recognition at 3m (%)**	**Recognition average (%)**
Hoy	20	0	0	0	0	0	20	28
Vamos	40	40	0	20	40	0	20	**42,67**
Tener	60	20	0	40	0	60	40	**53,33**
Ayuda	60	20	0	40	0	60	40	**42,66**
Especial	20	0	0	0	0	0	0	37,33
Presento	30	50	30	20	30	0	0	**38**
Nao	40	20	20	40	0	0	0	20
Va a ser	80	60	60	60	40	80	80	**68**
Coterapeuta	0	10	0	0	0	10	0	12,67
Hola	20	60	80	90	60	90	80	**65,33**
Hola Nao	20	60	80	80	60	80	60	**45,33**
Ayudar	20	0	0	20	0	20	40	33,33
Hacer	20	60	80	60	60	60	20	**68**
Ejercicio	80	80	60	40	20	10	0	**38**
Servir	40	20	40	0	40	80	0	**49,33**
Reflexionar	20	40	0	20	0	0	0	**44**
Dolor	0	0	0	0	0	0	60	16
Impide	20	20	0	0	0	0	20	32
Cosas	0	0	0	0	0	0	20	29,33
Queremos	0	0	0	20	20	0	0	4
Estrategias	0	20	20	0	0	0	0	28
A pesar	20	60	20	60	100	60	100	**78,66**
Ahora	40	60	20	20	60	60	40	**64**
Le dejo	0	0	0	0	0	20	0	18,66
Que siga	20	40	60	0	60	20	20	**60**
Gracias	70	70	70	80	40	60	30	**66**
Muchas gracias	20	30	30	50	20	0	20	34
Gracias Nao	20	20	40	40	30	20	0	37,33
Muchas gracias Nao	0	20	0	0	0	0	0	6,66

Once it was done, other tests were done to find exactly the most discriminable words between the most recognized words. Moreover, if any parts of these words was more discriminable that the own word, this part was selected to list in the best recognized fragments. The results for each part are shown below:

Table 7. Finally selection of the words to recognize

Narrative Part	Part of the narrative to recognize	Words to recognize	Threshold
Introduction	*Hoy vamos a tener una ayuda especial.*	Hoy; hoy vamos; hoy vamos a tener	40
Introduction	*Os presento a NAO.*	Os presento a Nao; Presento a Nao; Nao	40
Introduction	*que va a ser mi coterapeuta hoy. Hola NAO.*	Hoy; hola; hola Nao	40
Introduction	*NAO me va ayudar a hacer un ejercicio que nos va a servir para reflexionar sobre cómo el dolor nos impide hacer las cosas que queremos.*	a a; jercicio	40
Introduction	*Muchas gracias NAO.*	gracias	40
End	*Muchas gracias NAO.*	Gracias; nao	40

3.2 INTEGRATION

A video which shows the final result with the integration of the parts and the procedures is attached.

4 CONCLUSIONS

By drawing on evidence from positive psychology and mood induction, our goal was to build a library of postures to induce positive emotions with a humanoid robot that is affordable to be used by therapists on a regular basis. With this aim, we have studied the relevant research on positive psychology and mood induction, along with previous approaches to human and robot expression of emotions and perception of emotional stimuli.

According to the previous sections, one of the best methods to induce positive emotions is through a film with instructions. Pictures and sounds are very important MIPs too.

On the other hand, human-robot interaction is mainly based on human social interaction. One of the most important features in social interaction is communication. In fact, we know the teacher-learner method is the most popular social learning procedure in human-robot interaction, which is based on imitation. It allows for the transfer of information, such as behaviors, according to Bandura's *social cognitive theory*, which is an example of a transformational theory. Transformational theories suggest that the information that is required to display certain behavior is created internally through cognitive processes, and observing these behaviors provides incentive to duplicate them. So, our hypothesis is that if we observe a positive mood in a humanoid robot it causes a positive mood contagion in us.

A mood is an emotional state. It is known that body language is also used here as a basis for the expression of emotions. Many experts confirm that the majority of human communications are made nonverbally (50-80%) [64].

Body language goes both ways:

- Our own body language reveals our feelings to others.
- The body language of others reveals his feelings.

Body language depends not only on body positions and movements. Body language potentially covers the following topics:

- Body Position: how we position our bodies.
- Proximity: proximity or space between us and another person.
- Facial expression
- Others: eye movement and gaze direction or auditory cues (Pitch, Pace, volume, volume variation, intonation and musicality).

Consequently, the main goal of this project is to find out how a humanoid robot can express positive emotions through body language, but without facial expressions, since our target implementation is a commercially available and affordable humanoid, such as NAO, that can easily be used by therapists.

We have developed previously a library containing a repertoire of body poses expressing positivity (happiness and enjoyment) to be combined as part of mood inducing procedures and therapies [1]. We believe that exploiting a rich body language set can compensate the lack of facial expressions in NAO.

In this project we have applied the postures and knowledge of [1] in a concrete application. A mood induction procedure to motivate and transmit positive emotions to patients with fibromyalgia.

5 FUTURE LINES

A series of experimental therapy sessions with actual patients are scheduled for the coming weeks with the collaboration of Labpsitec research group. In particular, we plan to use it for inducing positive emotions in order to promote self-efficacy and motivation to perform meaningful activities. The treatment program includes one group session of CBT with the support of NAO for inducing positive emotions in order to promote self-efficacy and motivation to perform meaningful activities. Patients will be assessed at pre-session and post-session for the intensity of pain, fatigue, mood and some emotions.

5.1 PARTICIPANTS

The sample will consist of women diagnosed with fibromyalgia who attend regularly therapy sessions in Labpsitec. The first session, which is already done, has a group of seven patients.

5.2 DESIGN

The experiment was designed to test how familiarized with new technologies people is, what are the differences before and after doing the mindfulness session in clinical aspects, such as dolor, fatigue and mood, in emotional aspects, such as happiness or sadness, and how is perceived NAO actions in a qualitative way.

5.3 MEASURES

According to [2], fibromyalgia is a term coined by Kahler Hench in 1976. Their name comes from the root *'fibro'* (fiber, referring to the connective tissue), *'myo'* (muscle), *'algos'* (pain) and *'ia'* (condition). Psychological aspects play a major role in fibromyalgia, given that chronic pain involves suffering, which increases the discomfort and decreases the quality of life of the individual. The literature estimates that 32.3% of fibromyalgia patients suffer anxiety symptoms, and depressive symptoms 34.8% [124-125].

The Initiative on Methods, Measurement and Assessment in Clinical Trial (IMMPACT) developed guidelines for the purpose of evaluating the effectiveness of treatments in patients with chronic pain. In this regard, they noted the importance of assessing various aspects:

- General measures of pain.
- Measures of physical functioning.
- Measures of emotional functioning: results from numerous studies suggest that chronic pain is often associated with various emotional states, including depression, anxiety, anger and irritability. It is also associated with various psychiatric disorders.
- Measures of satisfaction and overall impression of the changed.

The most commonly used measures in the field of chronic pain are self-reports. We are going to carry out measures of pain intensity, fatigue intensity, quality of mood and emotions intensity by visual analog Likert scale intensity 0-10 scales (pain intensity and fatigue), a 1-7 scale mood with 7 facial expressions, ranging from 1 (maximum sadness) to 7 (maximum happiness). To evaluate the effectiveness of induction of emotions a Visual Analog Scale of intensity in different emotions (VAS) [126] will be used. The participants will be asked to evaluate different emotions (happiness, sadness, anger, surprise, anxiety, relaxation / tranquility, disgust and enjoyment) experienced at a given time. The scale has seven possible responses, ranging from 1 (none) to 7 (totally).

The administration of these instruments was performed before and after the mindfulness session, an exception of TICs test before induction and a quality features of NAO and the preference of its use in the therapy after doing the session will be realized.

5.4 PROCEDURE

Participants were offered the psychological treatment and were asked to sign an informed consent form.

The content of the treatment program will have the following two main components: EMMA, a virtual reality environment for induction of positive emotions and motivation and NAO, a humanoid robot to increment the induction of positive emotions.

According to [9], in this study the environment of the meadow was used with music, sounds, colors, images and narratives especially to induce positive emotions and promote activation of motivation selected and behavior. The music was selected following two methods. On the one hand, melodies were selected following two rules of musical structure: the tempo and the mode [127]. The tempo is associated with the activation dimension, fast tempo tends to evoke energy and activation while the slow tempo tends to evoke calm and relaxation. Mode relates to the dimension of affective valence, higher mode associated with happiness and a minor mode is associated with sadness [128]. Famous melodies with fast tempo and major mode were selected. Moreover, resources belonging to the System International Affective Sounds (IADS) were selected, taking as a criterion in this case the affective dimensions of valence and arousal [129-130]. Melodies with positive valence and high arousal were chosen. Regarding the selected images standardized in the International System Affective Picture (IAPS), which met criteria for positive valence and high arousal while other images were used from different sources, which were selected taking into account three dimensions: color, brightness and saturation. Research indicates that for induce positive emotions is important that images have bright colors and high saturation. Positive emotions are mainly elicited by green and blue colors [131]. In addition to the sights and sounds were incorporated narratives especially designed for evoke positive emotions and motivation in patients fibromyalgia (see Annex I). The narratives were made by the treating team of Labpsitec research group with extensive experience in cognitive-behavioral therapy.

In the first test session, the robot NAO was used at the end of the session. It was administered in groups. This component was approximately 20 minutes. Patients were asked to complete measures pre-induction. NAO will tell them to concentrate on the screen and to maintain an open attitude to what offered. Following these instructions the induction will begin. After induction, they will be asked to complete post-induction measurements. Additionally, a 5 point auto-scale TICs profile (1: no knowledge, 5: expert level), a point auto scale agreement (1: totally disagreement, 5: totally agreement) to evaluate the social interaction with NAO, such as the membership degree, consideration as a co-therapist and global satisfaction, and to evaluate the quality features of NAO, such as the synchronization between voice and movement, the synchronization between music and movement, the fluency of the movements, the tone of the voice, the volume of the voice, the speed of the instructions, the movement speed, the naturalness of the interaction with the robot, the appearance, the expressiveness, the intelligence of the robot and the understanding of its speech, will be done. A 3 point auto-scale preference use of NAO in future sessions will also be asked (with, indifference or without).

To analyze the results obtained, we pretend to use the statistical test ‘Cohen’s d’ to show the effect size of the differences between the pre-post session results. Cohen's d is a measure of effect size. It is a relative measure of the difference between means of two populations compared to the dispersion relation of these two samples. Generally considered a d around 0.2 is a small effect, one d around 0.5 a moderate effect and d above 0.8 a large effect.

In addition, we would like to improve the system using the new available tools of NAO software, which are available in the new firmware version [39].

6 ANNEX I: Mindfulness session

The mindfulness session has been made for Labpsitec members and is inspired in [18] and [9].

Participants were instructed in the rationale for mindfulness as a treatment for FM (e.g., its role in focusing attention on pain and other pain maintenance symptoms, paired with the possibility of refocusing attention on the present moment and on other cues unrelated to pain). Participants were also taught mindfulness skills to observe, describe, and participate in experiences in the present moment without judging and while decentering from pain. While participants were immersed in the VR, the system provided instructions on how to observe the different elements offered by the beach and the meadow scenarios how to remain focused in the present moment, and how to participate in the experience without making any judgments.

6.1 VIRTUAL REALITY AND ENVIRONMENT

The following devices were used in this study: two PCs, a large projection screen, two projectors, a wireless pad, and a speaker system. PC#1 had the graphical outputs from its graphic card connected to two projectors (with a resolution of 1,024 · 768 pixels and a power of 2,000 lumens). They were used to project the environment onto a horizontal screen of 4 · 1.5 meters that was placed on one of the walls of the room.

NAO is used to give the therapeutic instructions to the patients and launch the mindfulness video.

The patients were seated on the other side of the room to best view the VR scenarios. The application used in this research is called Engaging Media for Mental Health Applications (EMMA's) World and was developed within the framework of a research Project funded by EU (IST-2001-39192-EMMA). EMMA's World includes five scenarios designed to provoke different emotional reactions: a desert, a beach, a forest, a snowy landscape, and a meadow. The therapist can include different elements (music, sounds, narratives, varying weather, colors, texts, etc.) in the five scenarios to apply therapy using different emotions and different problems. This system has been validated as a mood induction procedure and it has proven useful for activation and processing of emotions in post-traumatic stress disorder, pathological grief and adjustment disorders.

In this study, we used the meadow. The users can see green grass, flowers, leafy trees, rocks, and butterflies in motion. They can hear birdcalls, footsteps in the grass, and different kinds of music. The patients were given mindfulness instructions (i.e., to observe, describe, and participate in experiencing the present moment) to focus their attention on the audio and visual cues offered by the scenarios to promote decentering from pain (see Fig. 17). To promote immersion, a large screen and a surround audio system was used. A full description of this environment is presented in [18].

Figure 45. Treatment setting for the delivery of virtual reality (VR) sessions for training in relaxation and mindfulness skills in a group format. Color images available online at www.liebertpub.com/cyber

6.2 THERAPEUTIC STORY (IN SPANISH)

Part 1:

The exercise begins with all participants sitting in the chair. The therapist asks the patient to fill in the pre-tests. Then NAO stands up and is presented by the therapist:

Therapist: *Hoy vamos a tener una ayuda especial. Os presento a NAO que va a ser mi coterapeuta hoy. Hola NAO.*

Once NAO stands, recognizes the words "Hoy vamos a tener" followed by "Os presento a NAO" and "Hola NAO". Then, NAO answers and say hello.

NAO: *Hola, ¿cómo estáis? (Saluda).*

Therapist: *NAO me va ayudar a hacer un ejercicio que nos va a servir para reflexionar sobre cómo el dolor nos impide hacer las cosas que queremos y para tener más estrategias para poder hacer lo que queremos a pesar del dolor. Ahora le dejo a NAO que siga con el ejercicio. Muchas gracias NAO.*

NAO recognizes "ejercicio", after which he looks around prepared to recognize "gracias". Then, it answers and presents the mindfulness video.

NAO: *A ti, me encanta poder ayudar. Os voy a poner un vídeo en esta pantalla grande. Ahora os repartirán unas cadenas que vamos a necesitar. Cuando se proyecte el vídeo vais a ver que me muevo de acuerdo a las instrucciones del vídeo. Lo único que tenéis que hacer es hacer lo mismo que yo. Me veréis gesticular, usar las cadenas, moverme, e incluso bailar… Os animo a que me sigáis. Vamos a empezar.*

When NAO finishes the explanation it launches the video, turns around and sits in front of the video monitor.

Part 2:

The video is playing, the video content is shown below:

"Ya hemos comentado en sesiones anteriores qué ocurre cuando aparece la fibromialgia. Aparece el dolor el cansancio… y con él empiezan a desaparecer algunas pequeñas cosas, pequeños momentos que antes eran cotidianos y que ahora se antojan importantes. Trata de pensar en algo pequeño que hayas dejado de hacer y que eches de menos. ¿Cuántas cosas como ésta has dejado de hacer?.
Cada vez que has pensado o dicho: "No puedo" o "Tengo miedo", es como si algo te sujetara y no te dejara crecer, crecer en tus sueños, en tus ilusiones, en esa gran fortaleza que sabes que tienes, esa energía que te ha llevado hasta aquí, hasta el mundo de EMMA, porque en tu lucha de cada día, no has dejado de buscar una alternativa, una salida, una grieta en la cadena del miedo que te sujeta, para tirar de ella con todas tus fuerzas y liberarte.

NAO gets up, turns around and opens his arms and hands to allow the therapist put a chain in its hands. 10 seconds after NAO closes the hands grasping the chain.

Junta todos tus miedos en esa cadena ahora mismo e imagina que está alrededor tuya. (pausa) Ahora piensa en ti, en tu capacidad de querer, de luchar, de hacerle frente a la vida todos los días. Elige un sueño, una ilusión pequeña, algo que quisieras hacer desde hace tiempo…¿ya lo tienes?

NAO put the chain closer to its body stretching its arms.

Utiliza esa ilusión para luchar contra la cadena, cógela con tus manos y estira con ella con todas tus fuerzas. Cierra bien los puños, tensa tus músculos cuanto puedas, no permitas que se te escape, hazle frente al miedo y rompe de una vez esa cadena que te ata. Nota como se doblega, no hay nada más fuerte que la energía de la ilusión! Por eso estírala con todas tus fuerzas! (Sonido de metal rompiéndose!).

NAO is gradually released from the chain and throw out it according to what the video says.

Y ahora que eres libre ¿Qué quieres hacer? Disfruta de la sensación de poder, nada ni nadie puede impedirte despertar de tus sueños para hacerlos realidad. Levántate, aléjate de la cadena que ha quedado rota en el suelo, camina con el orgullo de haber vencido la batalla, con la renovada energía de la ilusión por vivir la vida como tú elijas hacerlo, estira tus brazos hasta el cielo, más, más, todo lo que puedas! Intenta tocar tus sueños.

NAO makes the gesture of strength and then walks around the room.

Disfruta de esta canción mientras tanto, y muévete libremente, camina, baila, haz lo que quieras, pero deja que crezca ese vigor nuevo mientras la escuchas.

Here, a song is playing in the video and NAO is dancing according to the lyrics and the rhythm of the song.

"Suelta cuerda, afloja ese nudo, de veras te juro, valga el juramento que nada es seguro.
Tu camino, delirios y espinos, no es menos sencillo, ni más empinado que cualquier camino. Es normal sentir temor, al redoble del tambor, fíjate que al otro lado está el valor.
Es muy fácil sólo tienes que saltar, este es el momento este es el lugar. Deja esa orilla atrás, confía, salta sin más. Sabes las razones y la dirección, sabes la manera y tienes la intención, porque antes ya saltó tu corazón.
No es preciso que estés preparado, lo que ha de saberse para no exponerse está al otro lado.
No hay secretos, no hay trucos ni atajos, tan sólo hay un salto, dos puntos distantes y miedo debajo.
Es normal sentir temor, al redoble del tambor, fíjate que al otro lado está el valor.
Es muy fácil sólo tienes que saltar, este es el momento este es el lugar. Deja esa orilla atrás, confía, salta sin más. Sabes las razones y la dirección, sabes la manera y tienes la intención, porque antes ya saltó tu corazón.
Es muy fácil sólo tienes que saltar, este es el momento este es el lugar. Deja esa orilla atrás, confía, salta sin más. Sabes las razones y la dirección, sabes la manera y tienes la intención, porque antes ya saltó tu corazón.
Es muy fácil sólo tienes que saltar, este es el momento este es el lugar. Deja esa orilla atrás, confía, salta sin más. Sabes las razones y la dirección, sabes la manera y tienes la intención, porque antes ya saltó tu corazón.
Suelta cuerda, afloja ese nudo, de veras te juro, valga el juramento que nada es seguro.
Tu camino, delirios y espinos, no es menos sencillo, ni más empinado que cualquier camino."

Part 3:

After the exercise the Therapist gives thanks to NAO. NAO recognizes "gracias" and returns the thanks to the Therapist and the patients for letting it participate in this exercise. Finally goodbye to everyone.

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