Home Automation for People with Autism Spectrum Disorder

Jéssica Santo[1(✉)], Caique Z. Kirilo[1], Marcelo Nogueira[1,2], Nuno Santos[2,3], Ricardo J. Machado[2,3], Luiz Carlos M. Lozano[1], Álvaro Prado[1], and Juliana Carvalho[1]

[1] Software Engineering Research Group, Paulista University, UNIP, Campus Tatuapé, São Paulo, Brazil
[2] School of Engineering, ALGORITMI Centre, University of Minho, Guimarães, Portugal
[3] CCG/ZGDV Institute, Guimarães, Portugal

Abstract. In an effort to reduce the crises of people with autism spectrum disorder and increase their safety, a study was conducted on home automation so that, through a medical protocol, it will be possible to configure situations and actions that should be put into practice when the system identifies that the autistic stress level is high. In addition, some studies were necessary to understand how the autistic mind works, based on the literature and interviews with specialists in the field. Through the developed system, it is possible to minimize the daily crises that occur inside the home, working together with the treatments of chromotherapy and music therapy.

Keywords: Autistic Spectrum Disorder · Stress level · Chromotherapy · Music therapy

1 Introduction

Autism, from the Greek autós, means "of oneself". The term autism was coined in 1908 by Eugen Bleuler, a Swiss psychiatrist who used the term to describe the escape from reality into an inner world (Cunha 2012).

The history of discoveries and achievements of autism is recent, it was classified as a disorder of cognitive development in 1978, however, only in 1993 the syndrome was added to the International Classification of Diseases of the World Health Organization.

Autism, according to Halpern (2019):

> "Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by difficulties in communication and social interaction and by the presence of repetitive or restricted behaviors and/or interests."

It is also considered a biological disorder that alters the brain's ability to understand sensory stimuli, which are perceptions of smells, tastes, textures, sounds, lights, colors, and everything that the human body is capable of feeling, making them sensitive to these sensations (Garreau 1994).

© Springer Nature Switzerland AG 2021
O. Gervasi et al. (Eds.): ICCSA 2021, LNCS 12953, pp. 119–141, 2021.
https://doi.org/10.1007/978-3-030-86976-2_9

Considering that technology has been an ally in different areas and has been helping in several difficulties faced by mankind, an intelligent, safe and cozy environment was thought, aiming to help in nervous crises occurring in autistic people. The research in intelligent environments works to develop facilities and systems in order to help people in their daily activities and promote the saving of resources without reducing comfort (Rosa 2015).

Automating certain areas of the home can increase the effectiveness of a treatment, transforming previously uncomfortable rooms into quiet, cozy, and safe spaces.

In today's age, contact with technology is constant. Throughout each technological evolution, new methods and discoveries have been made with the intention of making human life easier. One example is the evolution of lighting, from candles to lamps. Thinking a little further ahead, lighting is something necessary for all human beings, but for some people it can be something more, it can be part of a treatment, a way to calm down and slow down the pulse through chromotherapy for example. According to Sui (1992): "Chromotherapy is a science that uses color to establish balance and harmony of body, mind, and emotions.

Based on researches conducted by the American Psychiatric Association in 2006, color therapy proved to be efficient in treating diseases. With this in mind, a project was developed to automate the lighting of a house based on the level of stress in which the autistic person finds himself.

The measurement of the stress level will be the sum of two factors: tension in the muscles, which according to Cielo et al. (2014) can be caused by stress, and the heartbeat, since, if tachycardia occurs frequently, even standing still, it may be related to situations of stress or anxiety (Loures 2002).

Thinking about the sound sense, which also becomes more sensitive for autistic people, it was designed a system of anti-noise windows and ambient sound, based on the study of music therapy.

> "Music therapy is the professional use of music and its elements as an intervention in medical, educational, and everyday settings with individuals, groups, families, or communities that seeks to optimize their quality of life and improve their physical, social, communicational, emotional, intellectual, and spiritual health and well-being. Research, professional practice, teaching and clinical training in music therapy are based on professional standards according to cultural, social and political contexts." WFMT (2011).

The project also includes the automation of doors and windows with electric locks, ensuring the autistic's safety and helping the family's daily routine. It also has an emergency alert system for the family in case the stress level exceeds the average informed in the system.

According to the World Health Organization (WHO), there are approximately 70 million people in the world who have the Autistic Spectrum Disorder, and according to the study conducted by Goin-Kochel (2006), families with a higher family income usually receive the diagnosis of their child's ASD earlier than families with lower purchasing power, i.e., these people have better conditions to treat their children, because the sooner

the diagnosis is made, the earlier the treatments begin, and the chance of control and the very understanding of how it works is better.

It is known that autism is a disease that can disable a person from having an ordinary and even independent life, so thinking about actions, devices, and possibilities for improvement is essential for families and people with this disorder.

The more help there is, the better they will live. There may not be or have not been a resolution to the disease, but minimizing and controlling it is a big step for them.

The existence of families who need help in their routines for having a dependent person is justified by Buscaglia (2006) as being a complex experience, full of difficulties and extreme responsibilities, since the autistic person may be partially or totally dependent on his/her parents. With the researches done, the possibility of integrating technology in treatments performed in patients with autism, such as chromotherapy and music therapy, was seen, and it is also possible to contribute to safety and stress reduction.

The Hospital Israelite Albert Einstein informed that about 150 thousand new cases of autism are diagnosed every year in Brazil, estimating today about 2 million autistic Brazilians and approximately 407 thousand only in the state of São Paulo. Based on this data, a study was carried out on the average socioeconomic status of families with autistic. The responsible for the research was Brazilian Association of Research Companies (2008), which carried out the analysis with the participation of 150 caregivers (Fig. 1), and from this total, 70.6% belonged to classes C1 (family income of R$1391), C2 (family income of R$933) and D (family income of R$618).

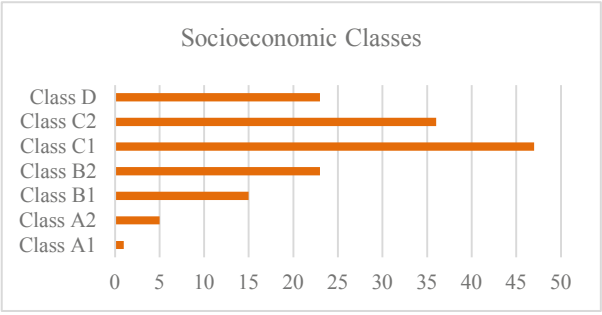

Fig. 1. Graphic of the socioeconomic survey. Source: Hospital Israelita Albert Einstein (2017)

Based on the data above, a project that would serve all families regardless of social class was elaborated, considering that there is the possibility of acquiring the equipment separately according to the individual needs of each autistic person.

2 Theoretical Reference

Autism

The Autistic Spectrum Disorder (ASD) is defined as a complex developmental disorder

that, from the behavioral point of view, has adverse implications on the development of communication and social environment (Gadia 2006).

According to the experts Sigman and Spence (2005), since it has not yet been possible to identify the causes, autism cannot be predicted or prevented, there is no cure or even particularly effective treatments.

Autism can manifest itself in varying degrees, however, certain signs can be considered "standard" and leading to diagnosis, such as repetitive and patterned behaviors with minimal interest in certain subjects and activities, absence of social interaction and communication. These symptoms can appear from early childhood, which corresponds to the period between birth and 6 years of age, and limit the individual's daily performance causing abnormal development (Gomes 2015).

In 1943, Kanner initially defined Autism as a condition with behavioral characteristics organized into three groups: social inability, language and communication problems, and the need for repetition, or sameness, then called Autistic Affective Contact Disorder.

Accordingly, Hans Asperger carried out a study called "Autistic psychopathy in childhood" in 1944, which confirmed the findings made until then, highlighting the preferential occurrence in early childhood boys who showed lack of empathy, low ability to make friends, motor mannerisms and unusual aspects in communication as tendencies to echo, they were also called little teachers, due to their ability to discuss a subject in detail.

In 1952, the American Psychiatric Association published the first edition of the Diagnostic and Statistical Manual of Mental Disorders DSM-1, which had nomenclatures, symptoms, and classifications used as a reference for researchers around the world.

During the 1950s, Kanner and Bettelheim supported the "refrigerator mother" belief, arguing that the disorder would be caused by emotionally distant family members, and the theory was called affective etiology or psychogenic theory. However, Bernard Rimland was the counterpoint to this theory, describing that there were four reasons to end the blaming of parents:

1. There were many parents who had other children who did not have autism;
2. If autism did indeed have a psychogenic origin, the disorder should disappear with psychotherapeutic treatment, which did not happen, according to studies based on this hypothesis;
3. The theory also defended the hypothesis that there had been a trauma in early childhood, but no patterns or reports were identified in which autism had started after a supposed trauma;
4. At least 23 parents in their database had been described as affectionate and cheerful, contradicting the idea of a "cold personality".

The year 1978 was marked with the understanding of the disorder. Michal Rutter classified autism as a disorder of cognitive development, proposing the definition based on four criteria:

1. Social delay and deviance not just as intellectual disability;
2. Communication difficulties such as absence of speech or even unusual use of it;
3. Unusual behaviors such as stereotyped movements and mannerisms;

4. Onset before 30 months of life.

The year was also marked by the elaboration of the DSM-3, where autism is recognized as a specific condition and is allocated to the new class called Invasive Developmental Disorders (IDD).

In 1981, psychiatrist Lorna Wing points out that autism is a spectrum of conditions and should be analyzed on different levels, since each individual could present specific difficulties. The term Asperger's Syndrome was coined.

According to studies conducted by Ivar Lovaas in 1988, the benefits of intensive therapeutic behavioral treatment were proven, with the result of his studies being an increase of 20 points on average in the IQ of children after two years of treatment.

In 2007, the UN established World Autism Awareness Day on April 2. In 2012, the Berenice Piana Law (12.764/12) was sanctioned in Brazil to guarantee the rights of people with Autism Spectrum Disorder.

In 2013, the DSM-5 started treating autism as a single diagnosis and aggregating different levels of severity. Asperger's syndrome, previously applied to milder cases, is no longer considered a separate condition.

Finally, within the current history, in 2015 the Brazilian Law of Inclusion of the Person with Disability (13.145/15) was created, increasing the protection of those with Autism Spectrum Disorder.

Spectrum disorder is a mental disorder that aggregates a diversity of conditions, but which have similarities and originate in some way from the same cause (Wing 1991).

Among the main symptoms of Autism Spectrum Disorder (ASD) are sensory difficulties. The brain of the person with ASD is unable to organize stimuli and give them meaning.

> "Human beings are born with the basic capacity for sensory integration, however, it must be developed through interaction with the world and the adaptation of their body and brain to the many physical challenges during childhood. "(Caminha 2008).

According to Ayres (1972), there may be direct problems in the learning process in the autistic brain because of this social integrative difficulty, causing inappropriate behaviors, affecting his social life.

Sensitivity is divided into two categories: hypo sensitivity and hypersensitivity, and affects the five senses: hearing, sight, smell, touch, and taste. Because it is a spectrum, each autistic person may have a different sensitivity than the other; one autistic person may have sensitivity in all the senses while the other has sensitivity in only one (Table 1).

Hyposensitivity is observed when the autistic person relentlessly seeks to put his or her body in contact with the sensation that will be caused, i.e., does not run away from the sensation, such as looking directly at light.

According to Gallina (2019), researcher Judith Bluestone pointed to a possibility that hyposensitivity is actually a result of extreme hypersensitivity, in fact, high sensitivity would cause the person to totally block out a certain sensation.

This characteristic can be considered dangerous, since they may not perceive exhaustion, thirst or hunger.

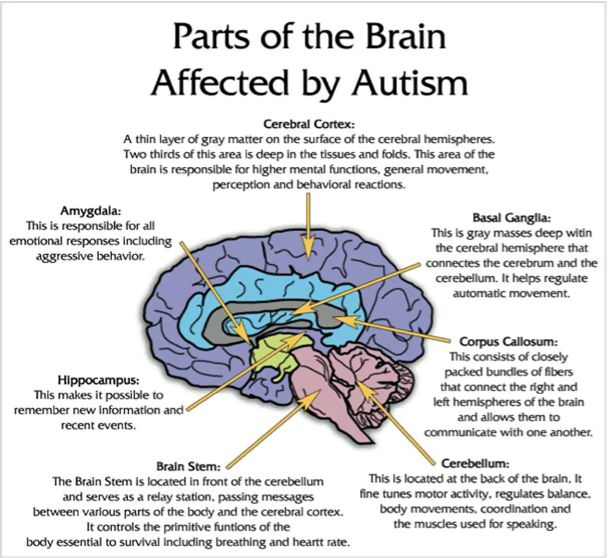

Fig. 2. Parts of the brain affected by autism. Source: (The theory of mind, 2013)

Table 1. Descriptive Table of Hypersensitivity and Hyposensitivity. Source: Book More than Words (SUSSMAN 2004)

Hypersensitive	Hyposensitive
Movement (Fig. 2)	
Difficulties in activities that include movement	Need to swing and turn
Touch (Fig. 3)	
Touch is painful and uncomfortable	High pain and temperature threshold and like heavy objects on them
Vision (Fig. 4)	
Vision is distorted and bright objects and lights fragment images	High concentration on peripheral vision, because central vision is blurred, and also great depth perception
Hearing (Fig. 5)	
Magnified noise volume, distorted and confusing sounds, inability to limit certain sounds, and difficulty concentrating. This results in a high sensitivity to auditory stimuli	Sounds are only heard with one ear and there is no recognition of particular sounds. These individuals like crowded and noisy places, kitchens, doors, and objects
Smell (Fig. 6)	
Selects food, people, and objects by smell	Likes specific smells

Hypersensitivity is extreme sensitivity, generally causing autistic to flee from uncomfortable situations. This is a very recurring characteristic among autistics.

The individual with sensory hypersensitivity, whose perception of stimuli is intense, when present in environments of high stimulation, develops aggressive, impulsive, and frightened behavior.

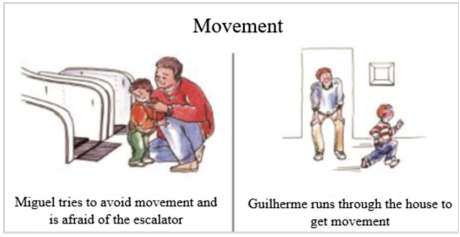

Fig. 3. Example of hypersensitive and hyposensitive – Movement. Source: Book More than Words (SUSSMAN 2004)

For autistic people who are hypersensitive to movement, there is a delay in motor development, problems with motor coordination, and a lack of dexterity.

The hyposensitive ones, on the other hand, have a need to be in constant movement, be it spinning, running, jumping, or swinging (Fig. 3).

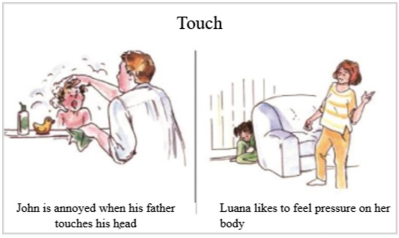

Fig. 4. Example of hypersensitive and hyposensitive – Touch. Source: Book More than Words (SUSSMAN 2004)

For autistic with hypersensitivity, characteristics such as fear of crowds, dislike playing games that can get them dirty, dislike being washed, combed or dried are common features for this type of sensitivity.

In the case of autistic with hyposensitivity, they have a high tolerance for pain, like to be upside down, and prefer tight-fitting clothing (Fig. 4).

Autistic with visual hypersensitivity avoid sunlight and glare because they cause headaches, dizziness and nausea when they use their vision, are afraid of moving objects, have difficulty determining distances, differentiate tones and colors, and do not like direct eye contact.

Autistic with hyposensitivity like to stare at lights or the sun, stare at moving objects, cannot perceive the presence of new people or objects in the environment, get lost when reading, and seek visual stimuli such as fans, pedestrians, fences, and textures (Fig. 5).

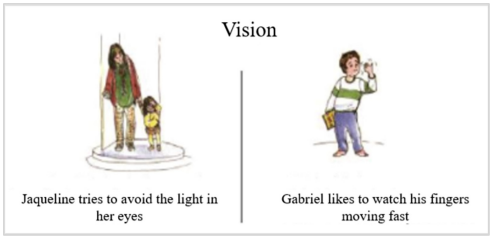

Fig. 5. Example of hypersensitive and hyposensitive – Vision. Source: Book More than Words (SUSSMAN 2004)

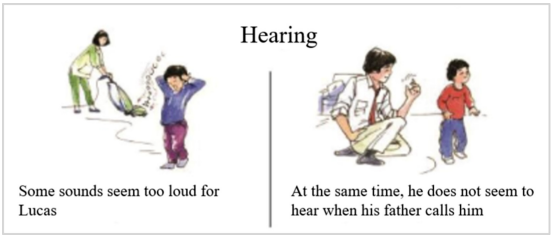

Fig. 6. Example of hypersensitive and hyposensitive – Hearing. Source: Book More than Words (SUSSMAN 2004)

Hypersensitive autistic, because they have very high sensitivity, usually cover their ears or hide in case of very loud sounds, avoiding noises such as high-pitched sounds, metallic sounds, and running water sounds.

Hyposensitive autistic like to talk loudly, prefer music and loud noises, making loud sounds in quiet environments (Fig. 6).

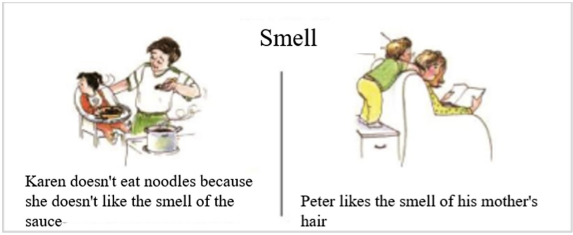

Fig. 7. Example of hypersensitive and hyposensitive – Smell. Source: Book More than Words (SUSSMAN 2004)

Hypersensitives avoid some smells because in some cases they become agitated. They choke on certain smells and foods are not attractive to them.

Hyposensitives like strong smells, preferring foods with strong smells, but have difficulty identifying certain smells, not identifying dangerous smells (Fig. 7).

It is known that autism is a developmental disorder and that it can present in varying degrees of severity. Despite these discoveries, the etiology of autism is still a matter of

debate in the field of science, since its origin and treatment are not known for sure (Rotta 2007).

In the mild degree, autism is classified by difficulties in social interaction, but a little lighter, problems in changing the activity they are doing at that moment and problems with organization and planning.

In the moderate degree, the deficit in social skills is a little larger, even when the autistic person receives support, either in verbal or non-verbal communication, there is a certain limitation to start a social interaction. The moderate autistic person has difficulty in facing changes and presents repetitive behaviors more frequently.

The severe level has a diagnosis of much greater deficit in verbal and non-verbal communication than the moderate level, with even greater difficulty in social interaction, because besides not initiating an interaction as happens in the other two levels, severe autistic are not open to social interactions with other people. Moreover, in this grade, repetitive behaviors are even more pronounced.

Treatments

- **Chromotherapy**
  Several ancient civilizations used colors as a form of health treatment. The Chinese believed that color was related to Mythology and Astrology, associating each organ of the body with a specific color. Among the Greeks and Romans, many philosopher-medics went in search of knowledge of this medical science with the Egyptian priest-medics who built the colorful city Heliopolis (city of light), where colors were used in the treatment of the sick.
  According to Dr. Galioughi (1983), medical treatment using colors began in Egypt, where priest-medics treated the sick with colors using flowers and precious stones.

  "Chinese, Egyptian and Hindu manuscripts of that time show that these peoples possessed a complete system of chromology based on the law of correspondence between the septenary nature of man and the septenary division of the solar spectrum" (Marini 2007).

  On the other hand, there are beliefs that Chromotherapy originated in Ayurveda, a medicine practiced in India thousands of years ago, which associated color with the chakras, seven spiritual points of the body located along the spine, applying crystals, sounds, breathing exercises, massage, and medicinal plants that act on the energy centers of the human body (Brennan 2006).
  Chromotherapy was recognized as a complementary therapy to traditional medicine by the World Health Organization (WHO) in 1976.
  Chromotherapy is a science that uses colors to restore balance and harmony to the body, mind, and emotions, with the understanding that each color has a specific vibration and therapeutic capacity. This restoration is performed at the energetic level, taking advantage of natural resources (light energy, physical and mental) to help strengthen the individual (Sui 1992).
  The body is composed of colored energies (vibrations) and to adjust it, it is necessary to use identical colors and energies, projected with various functions according to the area of vibration, stabilizing the balance and providing healing, since the visible

light spectra release healing potentials in the physical body. The choice of colors can restore the body, mind, and spirit to their natural balance, focusing on health, not disease (Table 2).
Below is a list of colors and their indications for treatments:

Table 2. List of colors and their indications for treatments. Source: Silva R. C. (2006).

Color	Indication	Physiological effects	Emotional effects
Red	People with heart failure reject the color	Super stimulates the nervous system, stimulates emotions, and aids in recovery from fatigue and general weakening	It produces nervousness, stimulates bad temper, produces severe headaches, produces morbidity
Orange	Suitable for depressives or people with dysrhythmia	Increases the vitality of the nervous system, accelerates bone metabolism, aids in kidney disease	Restlessness
Yellow	Indicated for intellectual work	Increases blood pressure and aids in strengthening the health of tissues, organs, and bones	Stimulates concentration
Green	Suitable for hospital environments	It accelerates the liver metabolism, increases the speed of healing of post-operative tissues, lowers fever, and is a destroyer or decomposer of sick and dead cells	Tranquilizes the patient and improves balance
Blue	Indicated for children and for manic and violent patients	Lowers blood pressure, is soothing and mild anesthetic, refreshing	Reduces anxiety, stress, eliminates pain, and induces relaxation and sleep
Violet	Used in the treatment of serious infections. Do not use in the treatment of respiratory diseases, as it will stimulate the growth of lung virus	Antiseptic, regenerator of the exhausted and stressed nervous system with prolonged fatigue, and aids in tumor processes	In autism, blue stimulates a feeling of calmness and improved balance, representing lightness in the emotional aspect of the autistic person. The deepest of the colors, it transmits tranquility, harmony, and serenity

- **Music Therapy**
  In Ancient Greece, music was considered the Art of the Muses, being described as a divine revelation, and of extreme importance for harmonizing body and mind (Tyson 1981).

"While Hippocrates has been called the Father of Medicine, we can recognize Plato and Aristotle as the forerunners of music therapy. Plato recommended music for the health of the mind and body, and to overcome phobic anguish. Aristotle described its beneficial effects on uncontrollable emotions and to provoke the catharsis of emotions" (Leinig 1977).

According to Podolsky (1954), for the philosopher Plato, music is capable of providing mental and physical health, and there are several demonstrations of music as a healing element in Greek mythology, such as that of the Greeks Zenocrates, Sarpender, and Arion, who used the harp as an instrument to soften violent outbreaks of mania, preventing the method used from being physical force.
According to Tyson (1981), during the Renaissance, the interaction of music with medicine occurred through the rescue of the theory of the four humors, which unified the four elements and four humors of the body that would derive the four temperaments and associating with the theory of music, having as a result:
Element - Air, Mood - Blood, Temperament - Blood (joy, optimism, confidence and extroversion), Music Classification - High.
Element - Water, Mood - Phlegm, Temperament - Phlegmatic (shyness, apathy and tiredness), Music Rating - Tenor.
Element - Fire, Mood - Yellow Bile, Temperament - Choleric (irritability, intensity, impulsiveness and quickness), Musical Rating - Soprano.
Element - Earth, Mood - Black Bile, Temperament - Melancholic (artistic inclination, sadness, fear and introversion), Musical Rating - Bass.
The elements would influence temperaments, so an imbalance of the elements could alter human behavior, thus causing mental illness. Music then was used by means of an analysis corresponding elements to sounds (Tyson 1981).
For the physician Robert Burton (1621), music is the possibility to lower fears and rages and to cure "annoyances of the soul". In relation to melancholy, he pointed to music as a means to cheer and revive the soul, however, he warned about the harm and illness that "music could cause".
With the advent of Empiricism, a theory that claimed that knowledge came only from sensorial experience, studies on the physiological effects of music began, using musical elements such as rhythm, melody and harmony (Tyson 1981).
According to Costa (1989), the French psychiatrist Jean-Étienne Esquirol recommended music to his patients, expanding its use inside psychiatric hospitals, as he believed that the order and metrics of music could help in treating the mentally ill, recovering moral norms and socially adaptable behaviors, and awakening emotions in his patients.
Only in the mid-20th century was music therapy considered as a profession and discipline, and it was widely used for the physically and mentally handicapped, people with neurological disorders, language disorders, and blindness.
Music is an art form present in all cultures, and has been used as a form of entertainment or even as a form of treatment for disorders and diseases (Gfeller 2008).

Music therapy is a science with interdisciplinary and multidisciplinary basis, since its theoretical body has influences and foundations, besides music, in areas such as Psychology, Education, Medicine, and Philosophy. The technique aims to aid communication and encourage the relationship, motivation, and learning of patients by studying their reactions to sound-musical stimuli. (Smith 2000).
The literature on Autism reports that there is an intense relationship between sufferers of the disorder and music, being an excellent element for the study and understanding of emotions, since it can provoke positive and negative responses even in individuals from different cultures (Brattico 2011).
The therapeutic value is found in the capacity that music has to produce effects on the human being on biological, physiological, psychological, intellectual, social and spiritual levels (Blasco 1999). From the psychological point of view, music can favor emotional and affective development, reducing the anxiety of daily life, stress, and insomnia. Physically, it activates touch and hearing, stimulating blood circulation, breathing and reflexes.

In general, the objective of Music Therapy is to provide the expression of feelings, whether in the form of words, sounds, or even silences, and can help improve the quality of life.

Technical scope

- **Automation**
  In the technical scope, the concepts of automation, internet of things and human-computer interaction composed the study.
  Automation is a technique of making a process automatic, being information flow tasks, services performed or products manufactured. According to Black, (1998), the greater the number of human functions performed by a machine, the greater the degree of automation.
  Automation is a technology that guarantees the success of a process, since it was programmed with the objective of performing one or more functions always in the same way, thus ensuring equity in each process and reducing errors.
  In this process, it is possible to apply the understanding of "surplus value" by Karl Marx (1983): "[…] reduction in working time and the corresponding change in the proportion between the two components of the working day […]". In other words, by increasing production through automation, manual work time is reduced.
  According to engineer Silveira, (2016), automation has seven main benefits, namely:

  - Productivity;
  - Cost reduction;
  - Quality improvement in the process and its result;
  - Safety;
  - Competitive advantage;
  - Precision;
  - Remote Monitoring.

- **Human-Computer Interaction**
  Human-computer interaction is an area of computing that is, by definition, interdisciplinary, since it studies the behavior of human beings in relation to technology, whether with cell phones, refrigerators, etc.
  The IHC potential is a combination of robot characteristics (eg adaptability, accuracy, speed) with the properties of human cognitive abilities (eg problem solving). To facilitate this collaboration, humans need to work safely and interact with the robot. Furthermore, the robot must adapt to human behavior and anticipate human needs. Indeed, cognitive factors, including topics such as communication and perception, can greatly benefit HRI in general and production applications in particular (Prati 2020). HRI is also a science that studies the interaction of humans with robots, focusing on their behavior and attitudes towards robots in relation to the physical, technological and interactive characteristics of robots (Dautenhahn 2013).
- **Internet of Things**
  The popularity of the Internet of Things (IoT) has been growing steadily given its versatility and applicability in various fields (Maskeliunas et al. 2019).
  According to Ashton (1999), "The Internet of Things" is a technological revolution with the purpose of connecting equipment used daily to the world wide web.
  In order for the Internet of Things to exist, it is necessary to use smart objects, that is, objects that are equipped with a form of sensor, microprocessor, communication device, and energy source (Vasseur and Dunkels 2010).
  According to Santos (2016), the fundamental tools used in the Internet of Things for data transfer and processing are arrangements of various technologies that enable the integration of blocks:

  - Computation: Executes the local algorithm on smart objects;
  - Services: It has four areas, namely:
  - Identification, designed to map physical entities of interest to the user into virtual entities;
  - Data Aggregation, responsible for collecting and organizing data;
  - Intelligent collaboration, determines the reaction to a certain imposed scenario;
  - Ubiquity, deals with collaboration intelligently at different times and places where they are needed.
  - Semantics: Responsible for extracting knowledge from objects in the IoT.
  - Identification: Defines whether the object can be connected to the Internet or not.
  - Sensors/Actuators: Collect, store and forward data to storage centers.
  - Communication: Techniques used to connect smart objects.

After identifying the key items, it is then necessary to adapt the existing protocols, since there are paradigms that need to be overcome so that the intelligent object network can reach the standards determined by the global network (Loureiro 2003).

3 Methodological Procedures

The present work is characterized by exploratory, descriptive and explanatory research with the outlines of bibliographic research with a qualitative and quantitative approach, having as its nature the applied research, besides the experimental research.

According to Boccato (2006), the bibliographical research aims to solve a problem based on published theoretical references, evaluating and debating the various scientific contributions.

Applied research focuses on problems existing in the activities of institutions, organizations, groups or social actors. It is dedicated to detailed diagnosis, problem location, and solutions. It responds to the needs of "clients, social actors or institutions". Furthermore, it aims to generate knowledge for practical application (Thiollent 2009).

Exploratory research aims to provide greater familiarity with the subject, with a view to making it more understandable and explicit to the point where it is possible to build new hypotheses. It determines trends, environments, contexts and situations of study. (Gil 2007).

Descriptive research requires information about the subject to be researched in specific, describing its characteristics. This type of study aims to describe the facts and phenomena of a given reality (Trivinõs 1987).

Explanatory research presents the factors that determine or contribute to the occurrence of events, thus explaining the reason for each event through the results found. It can also be defined as the continuation of a descriptive research, since after the identification of the factors that determine a phenomenon, it is necessary for it to be described and detailed (Gil 2007).

For greater assertiveness in this study, a free interview was conducted as a method of communication, with a psychopedagogue with experience and direct contact with an autistic child, in order to understand more thoroughly the difficulties of the target audience of this study.

For the execution of this work, a bibliographic research was carried out, with the purpose of deepening the knowledge about the Autistic Spectrum Disorder, its levels and characteristics. An analysis was also made to define the sensory aspects that could be helped by technology in their treatment.

In sequence, a survey of requirements, prototyping and screen specification was done to determine exactly what would be developed in the practical prototype.

As methodology, we have:

- Free Interview as a communication method.
- Exploratory, descriptive and explanatory research.

And as fundamental methods for carrying out the research:

- Bibliographic research, with the purpose of deepening the knowledge about the Autistic Spectrum Disorder, its levels and characteristics.
- Requirements survey, prototyping and specification of the system screens.
- Development of the prototype.

4 Case Study

A field study was conducted with a psychopedagogue with experience and direct contact with an autistic child. In this study, it was discussed the benefits of having treatments

like music therapy and color therapy in the home and how they could help in controlling and reducing the crises. It was also discussed the facility of having a record of the occurrences, heartbeat and muscle tension measurements for medical follow-up, helping in the direction of the treatments.

The question was raised to what extent the autistic can benefit from the automations presented, and the answer was the improvement of life in their routine, not only of the autistic, but of their legal guardians, by being confident that the house is properly equipped to better maintain the safety and comfort of those who need it.

5 The Prototype

The work consists of a set of automations and software that communicate with each other becoming a system that automates analog aspects of a residence according to the user's needs, manually or through analysis of the level of stress presented, aiming to assist in crisis control and in treatment of disabled people with Autistic Spectrum Disorder.

The objective of the software consists in controlling and monitoring the states of each automatic object installed in the user's residence, through its initial buttons, it is possible to change the state of an object and verify its current state, to make this control possible, the system has direct communication with the arduino (Fig. 8).

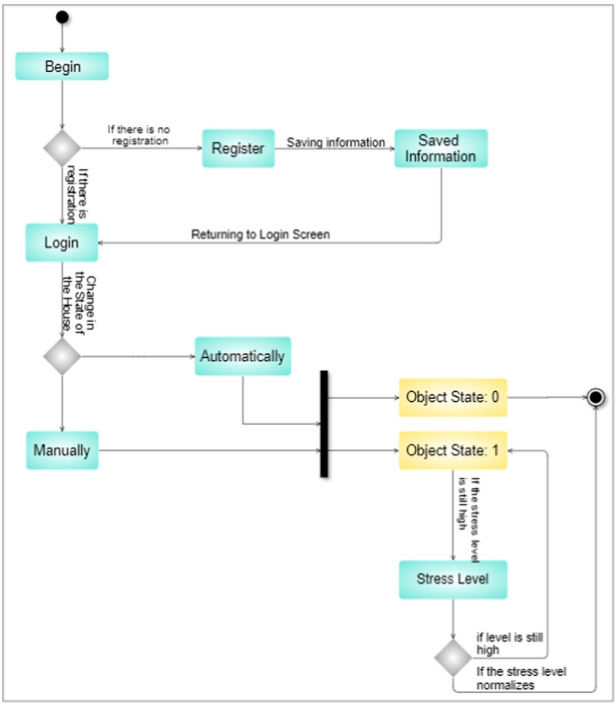

Fig. 8. State machine diagram. Source: Own Authors

The insertion of data and definition of situations and actions that should be put into practice when the system identifies that the autistic's stress level is high, will be done by the desktop system developed to configure this information. The system has as input the analysis of the user's stress level in the form of values identified via sensors and the manual input via the user's own request, that is, from an analysis of values and verification of requirements for each type of change, there will be a result as output of the change in the current state of the requested objects automatically, also allowing punctual changes without the need of an analysis of the stress level presented by the user (Fig. 9).

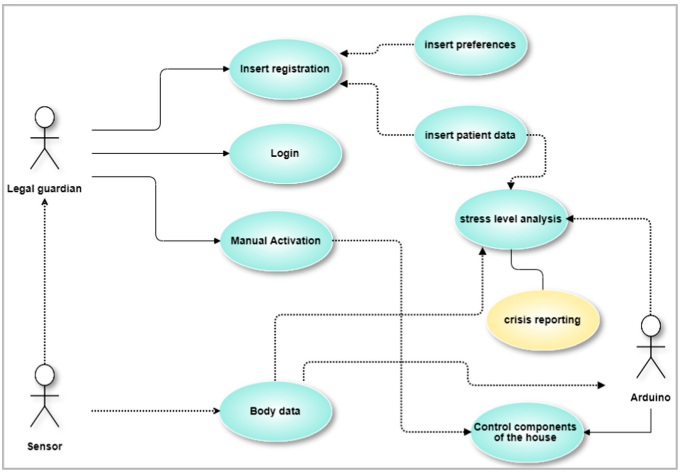

Fig. 9. Use case diagram. Source: Own Authors

The system will receive information about the level of stress and, according to the configured parameters, will analyze these settings regarding the necessary actions that should be put into practice in order to help in a possible crisis.

The communication is made between a Java object-oriented system, muscle and heart beat sensors and an Arduino board which controls the state of the house objects (Fig. 10).

The main objective of the arduino is to control the mechanisms that make objects that were previously analog or manual automatic, such as: the anti-noise system for doors and windows, the emergency door and window locks, and the lighting system.

In the project, for the anti-noise system to be possible, there are installed on the doors and windows of the house, fabric shutter curtains with acoustic insulation, which are activated via arduino, controlled by the software, with the purpose of inhibiting the internal noises that reach the residence.

The emergency lock system is composed of automatic locks, which in communication with the arduino and the main software, lock the doors and windows, so that in an emergency occurrence detected by the system, the locks are activated at the same moment, with the purpose of protection against a possible exit of the user or entrance of a third party whose risk of danger exists. The lighting system is composed of lamps that

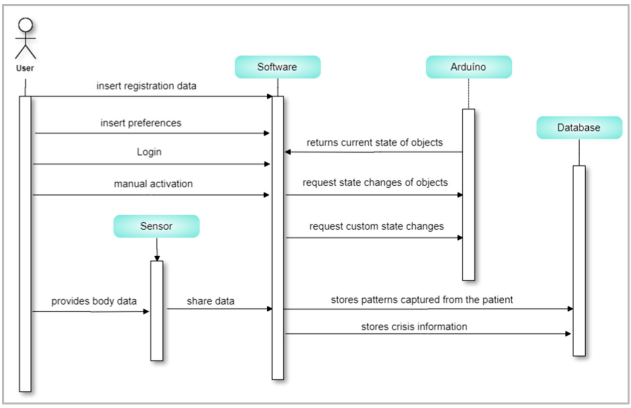

Fig. 10. Sequence diagram

have light level control and allow the change of the lighting color. The main objective of making their control automatic is so that there is total manipulation of the influence that the lighting states have on the user, once the software detects the need to change the current state of the light in a certain room, there is an instant change, making the environment as adapted as possible to the user's needs.

In general, the objective of the system is to provide interaction with all the components of the project, arduino, components of the residence and mainly the user, as well as an operating system provides communication between hardware and software, the system built in this project, has the purpose of being the main communication between user and machines, having as the only goal, to provide comfort and security for the main user and other residents of the residence (Fig. 11).

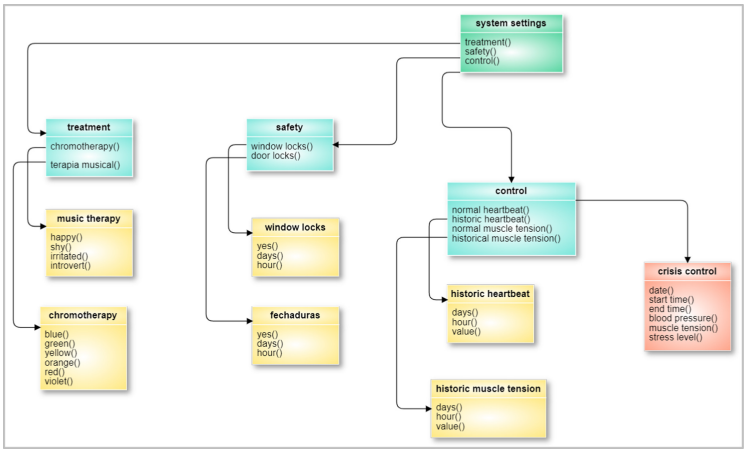

Fig. 11. Entity relationship diagram - system control. Source: Own Authors

The system can be activated in two ways: manually or automatically.

Manually, the user requests the change of state of the automatic component and from this request, the system sends an order to the Arduino, changing the state of the object, and keeps the information of the current state of the component, for example, the user requests the system to activate the anti-noise system of the doors and windows of the house, the system sends the order to the arduino, which activates the automatic blinds so that they cover the doors and windows, after the action of the Arduino, the software registers that the current state of the anti-noise system is active, leaving as the only input option, the request to deactivate the anti-noise system.

Done automatically, by reading the user's current stress level, for this input option, it is necessary for the system user to customize the way about which components of the house he would like to change and which state he would like depending on his stress level. Once the requirements to be changed are selected, the software will make the configured changes according to the user's stress level input.

As mentioned before, the measurement of the stress level will be given by the sum of two factors: muscle tension, which according to Cielo et al. (2014) can be caused by stress, and the heart rate, since, if tachycardia occurs frequently, even standing still, it can be related to stress or anxiety situations (Loures et al. (2002).

The human body presents a series of tension points, called trigger points. However, the most common point related to stress is tension in the trapezius, a muscle located in the neck (Fig. 12).

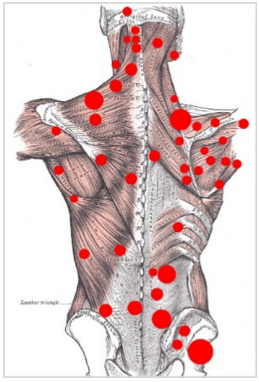

Fig. 12. Muscle tension points. Source: (Kelly 2017)

The sensor is responsible for picking up the electrical signal that the muscle generates when it contracts. It captures this small signal and amplifies it in the order of microvolts.

Regarding the alteration of the heartbeat, one of the most common causes, for people who do not have heart diseases, is due to stress situations.

Below is a table showing normal heart rate levels for women and men (Tables 3 and 4).

The sensors will work together, and if at any time only one of the two sensors identifies a level that is outside the configured standard, the system will check the second sensor to see if there is any change.

Table 3. Table of normal heart rate for women. Source: (Paschoal et al. 2009)

	Between 18 and 25 years	Between 26 and 35 years	Between 36 and 45 years
Excellent	54 to 60 bpm	54 to 59 bpm	54 a 59 bpm
Good	56 a 61 bpm	60 a 64 bpm	62 a 64 bpm
Below average	74 a 78 bpm	75 a 76 bpm	74 a 78 bpm

Table 4. Normal heart rate table for men. Source: (Paschoal et al. 2009)

	Between 18 and 25 years	Between 26 and 35 years	Between 36 and 45 years
Excellent	45 a 55 bpm	49 a 54 bpm	54 a 59 bpm
Good	57 a 61 bpm	67 a 61 bpm	60 a 62 bpm
Below average	71 a 73 bpm	72 a 74 bpm	73 a 76 bpm

The sum of these two factors, when above normal, will automatically trigger the system, which will have the function of identifying the best way to help the crisis to decrease or not to happen at all (Fig. 13).

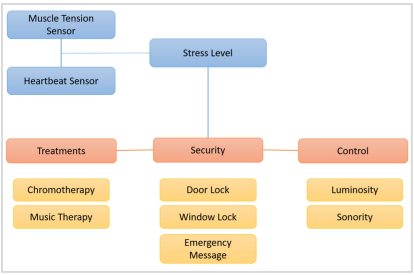

Fig. 13. Flowchart of the complete system. Source: Own Authors

The system will have three help options, and they can be activated together or separately.

In treatments, the system has the options Chromotherapy and Music Therapy, each of which can be configured according to the user's preference, or following the system's suggestion that will be based, in the case of music therapy, on the theory of the four elements, and, in the case of chromotherapy, on the theory of colors (Fig. 14).

Regarding security, the system will be connected to doors and windows that will have the locks activated when the system identifies a high level of stress, being also possible its configuration according to the user's preference. To unlock the locks, it will be necessary to manually deactivate the system.

The system will also trigger alert messages, warning the registered emergency contacts that the autistic person has a high stress level and is possibly in a crisis (Fig. 15).

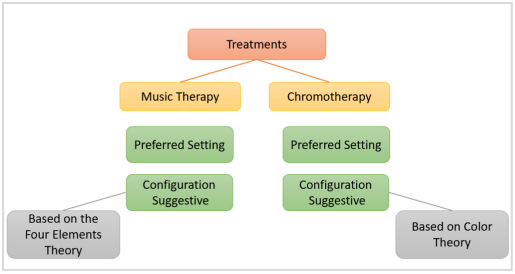

Fig. 14. Flowchart of the treatment system. Source: Own Authors

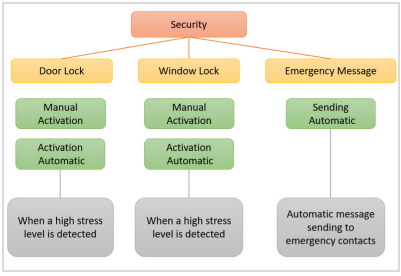

Fig. 15. Flowchart of the security system. Source: Own Author

In controls, the user can set the appropriate brightness level to make the autistic comfortable indoors, or he can leave the system Caiq automatic mode, adjusting the brightness as soon as it detects a brightness above the acceptable setting. The system will also activate the anti-noise windows when it detects a sound above the acceptable setting, also allowing the manual activation of this option (Fig. 16).

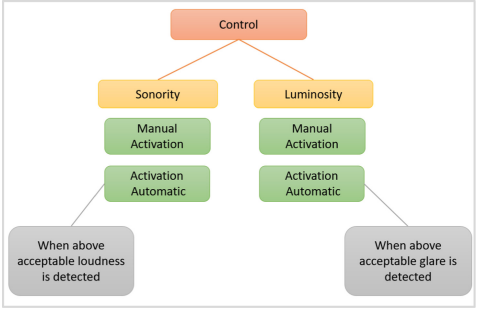

Fig. 16. Flowchart of the control system. Source: Own Author

6 Results e Discussions

From the case study, it was observed a sensitive improvement in moments of crisis, contributing to the control of anxiety and stress. Considering that this was a single case study, it was demonstrated that if this case study were extended to other people, it would become even broader and more effective.

In interviews realized with patients and their families, it was predicted that the system will be extremely beneficial in the daily control of the heartbeat, muscle tension and the stress level itself, providing a historic record that can be reported to the doctor with the date, time and the duration of the crisis.

7 Conclusion

With each passing day, the use of technology and artificial intelligence is growing and consolidating itself in the social sphere, actions that in the past were considered unimaginable are now part of everyday life, part of work, of family, of life. And it is with this thought of evolving people's knowledge and care, along with a desire that this subject does not stop here, with a mixture of satisfaction and social learning that this work was developed.

The system was thought of the autistic person and his/her family, being then a system of easy similarity and understanding, consisting of a cell phone or computer application, thus having an easy, fast and intuitive access, with an accessible price to all classes.

This was also an issue raised, currently, some existing equipment for the disabled in general, are marketed with high values for much of the population, which ends up making the cost and consequently the sale more expensive. The idea of ARSE is that it should be accessible to all classes, because this should go beyond commerce and profit, it should be a social project in search of improving the coexistence and experience with people who have this difficulty.

The study of the topic revealed to be ample and with potential for improvement even in the project that was presented in this article, providing future studies and analysis. For new studies, we will explore methods of detecting which of the human senses unleashed a crisis and which treatment was applied to reduce it.

The ARSE system has the intention of not only changing the way of life of autistic people, but that it is possible to change the technology called brain that exists inside each one, only then we will have a better society, able to respect everyone, always living in harmony.

Acknowledgements. "This work has been supported by FCT – Fundação para a Ciência e Tecnologia within the R&D Units Project Scope: UIDB/00319/2020".

References

Ayres, A.J.: Sensory Integration and The Child. Western, Los Angeles (1972)

Baptista, R.R., Cunha, G.D., Oliveira, A.R.: Aspectos fisiológicos e biomecânicos da produção de força podem ser usados no controle do treinamento de remadores de elite. Rev. Bras. Med. Esporte **14**, 427–430 (2008)
Black, J.: O Projeto da Fábrica com Futuro. Bookman, Porto Alegre (1998)
Blasco, S.P.: Compendio de Musicoterapia. Herder, Barcelona (1999)
Boccato, V.R.: Metodologia da pesquisa bibliográfica na área odontológica e o artigo. Rev. Odontol. Univ. Cidade São Paulo, São Paulo (2006)
Brattico, E., Alluri, V., Bogert, B.J., Vartiainen, N.: A functional MRI study of happy and sad emotions in Music with and without lyrics. Front. Psychol. **2**, 1–16 (2011)
Brennan, B.A.: Mãos de Luz: um guia para a Cura através do Campo de Energia Humana. Pensamento, São Paulo (2006)
Burton, R.: Anatomia da Melancolia (1621)
Buscaglia, L.: Os deficientes e seus pais: um desafio ao aconselhamento. Record, Rio de Janeiro (2006)
Caminha, C.R.: Autismo: Um Transtorno de Natureza Sensorial? PUC-Rio, Rio de Janeiro (2008)
Castells, M.: Sociedade em Rede: A Era da Informação: Economia Sociedade e Cultura. Paz e Terra, São Paulo (2002)
Cielo, C.A.: Síndrome de tensão musculoesquelética, musculatura laríngea extrínseca e postura corporal: considerações teóricas. Rev. CEFAC. **16**, 1639–1649 (2014)
Coriat, B.: A revolução dos robôs: o impacto sócio-econômico da automação. Busca Vida, São Paulo (1989)
Costa, C.M.: O despertar para o outro. Summus, São Paulo (1989)
Cunha, E.: Autismo e inclusão: psicopedagogia e práticas educativas na escola e na família. Wak, Rio de Janeiro (2012)
Dautenhahn: The Encyclopedia os Human-Computer Interaction. Berkshire Publishing school, Denmark (2013)
Espada, P., Martinez, O., Garcia-Bustelo, B., Lovelle, J.: Virtual objects on the Internet of things. Int. J. Artif. Intell. Interact. Multimed. **1**(4), 24–30 (2011)
Gadia, C.: Aprendizagem e autismo: transtornos da aprendizagem: abordagem. Artmed, Porto Alegre (2006)
Galioughi, D.P.: La Médicine des Pharaons (1983)
Gallina, L.P.: Toc Therapy: Design E Estimulação Multissensorial Para Crianças Com. Tea (Transtorno Do Espectro Autista), Bento Gonçalves (2019)
Garreau, B.: Effects of auditory stimulation on regional cerebral blood flow in autistic children. Dev. Brain Dysfun. **7**, 119–128 (1994)
Gfeller, K.: Music: a Human Phenomenon and Therapeutic Tool. American Music Therapy Association, Silver Spring (2008)
Gil, A.C.: Como elaborar projetos de pesquisa. Atlas, São Paulo (2007)
Goin-Kochel, R.P., Mackintosh, V.H., Myers, B.J.: How many doctors does it take to make an autism spectrum diagnosis? Autism **10**(5), 439–451 (2006). https://doi.org/10.1177/1362361306066601
Gomes, P.T.: Autismo no Brasil: desafios familiares e estratégias de superação. In: Belo Horizonte, M.G., (ed.) Faculdade de Ciências Médicas, Universidade José do Rosário Vellano (Unifenas), Brasil (2015)
Halpern, A.A.: Manual de Orientação: Transtorno do Espectro do Autismo. Sociedade Brasileira de Pediatria (2019)
Henschel, A.H.: Cognição Socila na Era da Interação Humano-Robô. Cell Press, Cambridge (2020)
Kanner, L.: Autistic disturbances of affective contact. Nerv. Child. **2**, 217–250 (1943)
Kelly, K.: O que são pontos de gatilho? Quiropraxia, notícias e artigo (2017)

Leinig, C.E.: Tratado de Musicoterapia. Sobral Editora Técnica, São Paulo (1977)
Loureiro, A.A.: Redes de sensores sem fio. Simpósio Brasileiro de Redes de Computadores, Uberlândia (2003)
Loures, D.L.: Estresse Mental e Sistema Cardiovascular. Arquivos Brasileiros de Cardiologia (2002)
Marini, E.: Cromoterapia: dicas e orientações de como as cores podem mudar sua vida. Nova Era, Rio de Janeiro (2007)
Maskeliūnas, R., Damaševičius, R., Segal, S.: A review of internet of things technologies for ambient assisted living environments. Future Internet **11**(12), 259 (2019). https://doi.org/10.3390/fi11120259
Paschoal, M.A., Trevizan, P.F., Scodeler, N.F.: Variabilidade da frequência cardíaca, lípides e capacidade física de crianças obesas e não-obesas. Arquivos Brasileiros de Cardiologia **93**(3), 239–246 (2009). https://doi.org/10.1590/S0066-782X2009000900007
Podolsky, E.:. Music Therapy. Philosophical Library, Nova York (1954)
Prati, E.P.: Como incluir a experiência do usuário no projeto de interação homem-robô. Robótica e Manufatura Integrada por Computador. Department of Sciences and Methods for Engineering University of Modena and Reggio Emilia, Italy (2020)
Rosa, V.P.: Protocolo de comunicação para localização de objetos na casa inteligente. Revista Militar de Ciência e Tecnologia (2015)
Rotta, N.T.: Transtorno de aprendizagem: abordagem neurobiológica e multidisciplinar. Artmed, Porto alegre (2007)
Sigma, M.: Autismo e seu impacto no desenvolvimento. Centro para a Pesquisa e o Tratamento do Autismo, EUA (2005)
Silveira, C.B.: Sete benefícios conquistados através da Automação Industrial (2016)
Singer, T.: Tudo conectado: conceitos e representações da internet das coisas. Práticas Interacionais em Rede (2012)
Smith, M.P.: Melodia e harmonia ditam ritmo do corpo. Folha, São Paulo (2000)
Sui, M.C.: Cura prânica avançada: manual prático de cura prânica com cores. Ed. Ground (1992)
Therapy, W.F.: What is Music Therapy? (2011)
Thiollent, M.: Metodologia da pesquisa-ação. Cortez, São Paulo (2009)
Trivinõs, A.N.: Introdução à pesquisa em ciências sociais: a pesquisa qualitativa em educação. Atlas, São Paulo (1987)
Tyson, F.: Psychiatric Music Therapy: Origins and Development. Wiedner & Son, New York (1981)
Vasseur, J., Dunkels, A.: Interconnecting Smart Objects with IP. Morgan Kaufmann (2010)
Wing, L.: The relationship between Asperger's syndrome and Kanner's autism. In: Frith, U. (ed.) Autism and Asperger syndrome, pp. 93–121. Cambridge University Press (1991). https://doi.org/10.1017/CBO9780511526770.003