UNIVERSITY CENTER FOR NEUROSCIENCE

RESEARCH YEARBOOK 2022

Authors:
José Rodolfo Pérez / María José Jiménez / Luciana Mejía Figueroa / Oscar Picardo Joao
Compiler: Oscar Picardo Joao

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Introduction

From the University Center for Neuroscience (CUN) of Universidad Francisco Gavidia (UFG), we present this monographic issue of Neuroscience that contains five studies carried out by the team of researchers, which respond to various particular and structural challenges: 1) "Executive functions and dyslexia: Status and evolution of Paula's case", from José Rodolfo Pérez; 2) "Psychological impacts of confinement and social isolation due to COVID-19 in preschoolers in the San Salvador area", from José Rodolfo Pérez; 3) "Comparison of normal studies vs. abnormal studies for the automatic detection of abnormalities using magnetic resonance imaging and techniques of machine learning", from María José Jiménez; 4) "Efficiency and safety of transcranial magnetic stimulation (TMS) in the treatment of juvenile depression", from Luciana Mejía Figueroa; y 5) "An experiment in ideological vulnerability", from Oscar Picardo Joao.

Neurosciences, as an interdisciplinary workspace focused on the study of the brain, have recently made its way in El Salvador; we already have young scientists who have specialized abroad and have created specific lines of research that begin to present their results.

The CUN is advancing scientifically at a good pace. Currently, a sophisticated neurophysiological laboratory was acquired to perform brain studies, the "Neuron-Spectrum-4/ EPM", through which studies of classical encephalogram, long-term encephalogram can be developed, neurofeedback, visual and auditory evoked potentials, among other processes: the equipment has 21 EEG channels plus eight polygraph channels to record EMG, ECG, EOG; high-quality EP recording and multimodality, advanced analysis tools, button lights, storage, cardiac and respiratory monitoring and remote monitoring. With this equipment acquired in Moscow, the UFG is at the forefront of research in Neuroscience and will provide better technology to children with various problems and learning disorders, such as autism spectrum disorder, attention deficit, hyperactivity, dyslexia, among other problems and characteristics.

Part of the CUN's scientific function is to communicate the results of the research, and in this context we present this publication being the first specialized series in the field of Neurosciences and possibly the first in the country. Next to the publications "Pedagogy, didactics and autism" (2018), "Education and COVID-19: study of factors associated with online academic performance in times of pandemic (case El Salvador)" (2020), and "The learning curve: a neuroevolutionary approach and neuroscientific" (2021), we continue to expand the collection of our scientific production from CUN-UFG.

With the support of Arizona State University (ASU), we will soon present a double Master's degree in Neuroscience, which will allow us to continue expanding local scientific capacities in the specialty, train specialists, open new lines of research and learn more about the brain.

Oscar Picardo Joao, PhD.
Director of the Institute of Science, Technology and Innovación (ICTI)
Founder of the University Center for Neurosciences (CUN)

Executive functions and dyslexia: status and evolution of Paula's case

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SUMMARY

Dyslexia is a condition that is associated with difficulties in learning and acquiring the processes associated with language. This phenomenon is a fairly heterogeneous set of behaviors, which is why diagnosis is a complex process and requires the appropriate psychometric tools. In this study, patient Paula is investigated, analyzed and treated. This is a nine-year-old girl diagnosed with dyslexia; In addition, Paula has abnormal epileptiform brain waves and a megacisterna magna at the cerebellar level. A single case study type ABA is conducted. The measuring instruments were the Stroop test, d2 Attention Test and the Neuropsychological Battery for Learning Disorders (BANETA), with which periodic measurements were made pre-treatment, during treatment and post-treatment. An intervention plan is drawn up and applied for four months, dealing with four axes of rehabilitation: perceptual, lexical, syntactic and semantic processes. Systematic measurements were made in all three phases (ABA). The results show that Paula increases her executive functioning when receiving the intervention, but only shows improvements in her phonological processing, that is, she becomes more capable in the recognition of words, but not in other areas of interest such as specialized auditory discrimination of simple phonemes or their units (consonants or vowels). Neurological conditions are likely to be strongly variable against treatment. For future research, the application of other intervention and measurement strategies should be considered.

Keywords: dyslexia, BANETA, Stroop test, neurological conditions, systematic measurements, El Salvador.

Introduction

The first observation of the phenomenon called dyslexia was made by Adolf Kussmaul in 1877, a medicine professor in Strasbourg, who identified it at the time as "blindness of words". On this basis, in 1887 the German ophtalmolohist Rudolf Berlin, through his professional practice, found the same phenomenon as Kussmaul, where certain adult patients had difficulties in reading words, there was no physiological cause at the level of the visual apparatus to explain the anomaly, so he assumed that the problem should be in the brain. Although due to the limited scientific advances of the time it was not possible to deepen in this aspect; nevertheless, motivated by other terms of the time such as alexia or paralexia, he aligned this phenomenon with the international medical literature and called it “dyslexia”.

For years the interest that existed on this problem decreased significantly, there were few publications during the first half of the twentieth century, until in the 60’s the neurologist Macdonald Critchley and psychologist Tim Miles resumed the study of dyslexia, conducting research on people who suffered from it contributing to the opening of The Word Blindness Centre, an institute specialized in the study and care of this condition. This revitalization by the study of dyslexia allowed, in 1968, the research section of the International Federation of World Neurology on Developmental Dyslexia and Illiteracy to provide for the first time a characterization of the problem, which is not only a problem, proposing that it should be understood as a disorder manifested by difficulty in reading, despite having received the usual training, without alterations in intelligence or sociocultural deprivation that could provide a better explanation of the condition suffered by the person.

During this resurgence of interest in dyslexia, researcher Naidoo published the first book on the subject: Specific dyslexia. From this period onwards, the study and understanding of the disorder increased and the interest in finding therapeutic strategies that facilitate adequate care every day became more varied.

According to the Diagnostic and Statistical Manual of Mental Disorders V (American Psychiatric Association, 2013) developmental dyslexia is a term in disuse, that falls within the category: specific learning disorder with difficulties in reading and writing. This diagnostic nosolology is characterized by a pattern of problems related to the recognition of words and written expression accurately and fluently (Snowling

et al., 2020). Sometimes these difficulties are accompanied by problems in the acquisition of spelling skills, as well as difficulties in the comprehension and practice of mathematical reasoning.

For this research, the term developmental dyslexia will be used only for practical purposes, although as has been clarified, nosolology as such has a different correspondence in the diagnostic manuals. It is also necessary to establish that this diagnosis is part of neurodevelopmental disorders because modern neuropsychological studies point to a biobased etiology of onset in childhood and related to alterations of the brain substrate. In this regard, recent research (Wagner *et al.*, 2020) estimates that about 5% -20% of children and adolescents suffer from developmental dyslexia in the United States, these figures are ambiguous and not representative of the prevalence of the phenomenon by diagnostic criteria, as for clinical disagreements about their identification and psychometry.

Developmental dyslexia is considered as the result of specific deficiencies in phonological processing, that is, the use of the sound structure of language as a way to process information, these cases present a deficit of word recognition or decoding (Lyon *et al.*, 2003; Peterson and Pennington, 2012; Wagner and Torgesen, 1987); in this sense, most research has tried to find the biological causes associated with poor performance in phonological processing at the structural and functional level, as presented in different publications (Caylak, 2009; Galaburda, 1999; Galaburda and Kemper, 1979; Krafnick *et al.*, 2014; Schlaggar and McCandliss, 2007; Shaywitz *et al.*, 2001; Temple, 2002).

A functional magnetic resonance imaging (fMRI) study (Demb *et al.*, 1999) of adults with dyslexia found that during phonological processing, the left hemisphere frontal lobe becomes heterogeneous (normal or hypernormal) and the language regions in the left temporo-parietal area do not manifest activity or do so in a hyponormal way. However, another research (Shaywitz *et al.*, 1998) with fMRI found a significant role of certain brain areas in the manifestation of dyslexia, such as: posterior superior temporal gyrus (including Wernicke's area), angular gyrus, striated cortex, and inferior frontal gyrus. These areas, unlike people without dyslexia, have deficits in the regulation of their performance on demand, that is, they do not achieve an adequate activation for the coding of the orthographic and phonological processing required for the good performance of an activity. This undoubtedly reflects a significant and fundamental

dysfunction of phonology, its processing and its compensation. Other studies (Paulesu *et al.*, 1996; Rumsey *et al.*, 1997) have found similar results, one of the differences has been the measurement technique such as Positron Emission Tomography (PET) that has incorporated visual and auditory stimuli, as well as the use of the PET scan, demonstrating again that people with dyslexia have a poor regulation of temporo-parietal activity, confirming the existence of dysfunction in the phonological loop, which overcome the cultural differences of language (Paulesu *et al.*, 2001).

In relation to the above, Temple *et al.* (2001) conducted a study with 24 dyslexic children and their control counterparts using fMRI: it was found that children without dyslexia manifested activation in the frontal and left temporo-parietal areas when performing rhyme reading and letter matching; on the other hand, children with dyslexia showed activation in the inferior frontal and insula rotation of the left hemisphere, but fail in the left temporo-parietal activation when they perform the same tasks as their control counterparts; this allowed the researchers to find that the deficit of children with dyslexia is especially phonological, since visual processing in letter matching does not activate the brain areas responsible for these processes as if it happens in children without developmental dyslexia. Similar results have been found in other research (Simos *et al.*, 2000), with the difference that magnetic source imaging (MIS) was used, a non-invasive procedure applied to 10 children with dyslexia and eight controls, where children with dyslexia presented: (a) Significant reduced activation of the left temporo-parietal area; and (b) Significantly greater activation in homologous areas of the right hemisphere, during latency periods, while they ran read tasks against their counterparts without reading problems. In this regard, this allowed the authors to conclude that the data is consistent with the hypothesis that reading problems associated with children with dyslexia present an irregular pattern and consisting of the functional connections of the areas of the brain involved in reading, as opposed to a general dysfunction of a particular area as might be assumed.

Temporo-parietal and parieto-occipital area dysfunction have a great deal of explanatory value; it has been proven by various studies and is an important source in the production of phonological processing deficit theories (Horwitz *et al.*, 1998; Krafnick *et al.*, 2014; Raschle *et al.*, 2012; Rumsey *et al.*, 1992). Also, the above mentioned, has been verified by several meta-analysis studies (Maisog *et al.*, 2008; McCandliss and Noble, 2003; Pugh *et al.*, 2000a; Pugh *et al.*, 2000b; Richlan, 2012; Sandak *et al.*, 2004; Schlaggar and McCandliss, 2007; Shaywitz and Shaywitz, 2005), which demonstrate

scientific findings in reading acquisition ability and dyslexia intimately related to three specific regions in the brain: (a) Temporo-parietal area, in some cases, may be seen as temporo-parieto-occipital area, responsible for the decoding of words; (b) Temporo-occipital area, responsible for visual language processing and, therefore, associated with orthographic recognition; and (c) Hyperactivation of the lower left frontal rotation, responsible for articulatory processes; in addition, of these areas in particular, the role of the arched fascicle is also contemplated as the structure that connects these cortical zones. This corresponds to the theory of phonological deficit as the probable cause of dyslexia, the lower left frontal rotation and the tempo-parietal and temporo-occipital areas fail in their functioning (in the reading and writing process), the former presents hyperactivation and the subsequent hypoactivation (Norton *et al.* 2015).

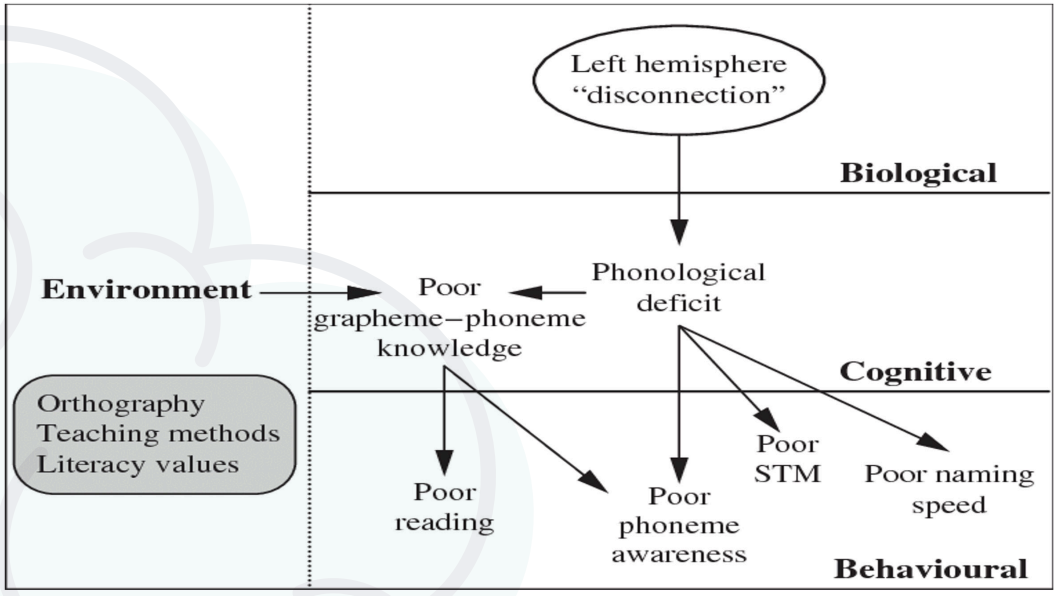
There are other hypotheses about the biological origin of dyslexia such as the approaches of anomalies at the magnocellular level (Livingstone *et al.*, 1991; Stein, 2001), deficits or motor and cerebellar anomalies (Chaix *et al.*, 2007; Nicolson *et al.*, 2001; Ramus, 2003), or problems related to temporal lobe level (Martino *et al.*, 2001; Rey *et al.*, 2002) or spatial visual areas (Livingstone *et al.*, 1991; Lovegrove *et al.*, 1980). However, due to the sufficient scientific evidence available, for this study, deficit phonological processing theory and its previously described neurological correlates were used as the basis for experimentation.

The theory of phonological deficit as an explanation for dyslexia is the one that accumulates the most empirical evidence in this regard. This cites that dyslexia has its origin in the specific difficulty for the formation of representations, storage and recovery of sounds corresponding to speech; this results in poor phonological coding, associated with other learning problems, such as reading or the acquisition of orthographic rules. In summary, phonological theory argues the existence of a direct link between a cognitive deficit and the behavioral problem: dyslexia.

The theory of phonological deficit as an explanation of dyslexia has a relatively simple functioning; among its main theorists (Shankweiler *et al.*, 1979; Vellutino, 1981; Vellutino and Fletcher, 2005) have managed to deepen in this in simple terms as shown by Frith and Frith (1970) in Figure 1, where the biological anomalies found in the left hemisphere are the basis of the deficits manifested in children with dyslexia.

Figure 1

Operation of phonological processing.



Source: Frith and Frith (1970).

The authors Frith and Frith (1970) consider that the phonological deficit of children with dyslexia affects the acquisition and correct knowledge of phonemes and graphemes, this directly affects the reading processes; in addition, the same phonological deficit it affects short-term memory and processing speed, because being closely linked to language development (phonetics, syntactic, etc.), variations in language acquisition or development will impact the entire functional system and executive functions accordingly.

Executive functions include skills such as planning, problem-solving, working memory, cognitive flexibility, and inhibition; executive functions play an essential role in the child's behavior, emotional regulation, and social interactions develop during childhood and adolescence. Children with dyslexia have deficits in this area, although the directionality of the relationship: executive functions-dyslexia (executive deficit-phonological deficit) is unknown.

A study (Akyurek and Bumin, 2019) conducted with a group of children with dyslexia and their healthy controls, intended to measure executive functions between both groups, found that there are statistically significant differences between children

with dyslexia versus those without this condition; children with dyslexia have a deficient performance with respect to their working memory, impulse control, problem solving, organization, emotional regulation and follow-up in the exercise of activities with respect to their counterparts. Another similar study (Barbosa *et al.*, 2019), points out that the existence of deficits in the executive functions of children with dyslexia compared to healthy controls is related to the processes of selective attention modulation, shift of attention and phonological processing, which are related to the processes of modulation of selective attention, movement of attention and phonological processing, the latter typically associated with dyslexia.

In another study (Varvara *et al.*, 2014), executive functions in children without and with dyslexia were analyzed, finding deficits in several domains of executive functions such as categorical and phonological fluency, visospatial and auditory attention, spunerism, verbal and visual short-term memory, and visual communication, verbal working memory in the latter. In addition, by exploring predictive relationships between executive function measures and reading, they found that spunerism better explains word and non-word reading deficiencies in children with dyslexia.

Empirical information obtained over time identifies a probable and close relationship between optimal development of executive functions and dyslexia in children. Although studies do not identify the intensity or degree to which one affects to the other or even if the relationship of influence is unilateral or bilateral. In addition, it is unclear how other cognitive areas may be affected and not be considered in the study. In short, it is evident that the phenomenon of dyslexia and its implications on executive functions is far from being defined in a forceful way. In this sense, for this study it has been considered to investigate this condition from a single case design (n=1), this in order to have an approach to the problem through a subject that not only meets particular conditions of dyslexia, but also a single case design, but it allows an analysis of the progress and setbacks before the application or withdrawal of treatment in speech therapy and psychoeducational therapy.

The analysis of this case, in particular, provides a first approach to the phenomenon in the salvadoran context, in relation to the implementation and measurement of treatments in a subject coming from our society and culture, it has a unique psychosocial configuration and allows the possibility of understanding more closely the reality of this condition. However, the results achieved are limited by the lack of

generalization, therefore, they cannot explain the wide range of manifestations of dyslexia in most children in the immediate environment of the study; in addition, this is a first approach to the problem and, therefore, it provides the ground for future larger investigations.

Method

Design

For this study, a n=1 design has been considered, due to the nature of the phenomenon, as well as the opportunity to make measurements of the patient Paula, a 9-year-old girl, in addition to other neurological particularities that make her a subject of experimental interest. The n=1 most suitable design for this ABA study (Kazdin, 2001) is that a baseline of the dependent variable, phase A, is drawn and then proceed to the planned intervention and again make a measurement of the same variable, phase B. The phases are repeated until three phases (ABA) are completed. The effects of the intervention should be clear during each phase, especially when treatment is withdrawn, phase A, approaching baseline.

Research n=1 type ABA is part of the experimental designs, its main characteristic is to carry out experiments with unique cases. In that sense, participants are considered whose clinical characteristics are statistically atypical and, therefore, they are considered to be a part of the experimental designs, it makes them a reference research subject for the application and measurement of novel treatments or previously established as ideal.

Participants

This study will be named with the pseudonym “Paula”, in order to maintain their privacy and confidentiality, both for being a minor, and for the ethical requirements related to research in people, according to “international, national and institutional parameters.

Paula's case is "exceptional", she is a 9-year-old girl, who suffers from phonological dyslexia, diagnosed from a series of psychological tests, namely: Neuropsychological Battery for the Evaluation of Learning Disorders (BANETA), Wechsler Scale of Intelligence for Children and Adolescents – IV (C.I.T.=78), Stroop Test and d2 of

Attention. These tests, specifically the first, are specially designed to diagnose learning problems. In addition, Paula underwent neurological analysis, the first of which was an electroencephalogram (EEG), which revealed abnormal wave tips in the frontocentral areas, which typifies the results as non-epileptic paroxysmal. The second neurological examination performed by the EEG results was a magnetic resonance imaging (MRI) that revealed an abnormality called megacisterna magna in the vicinity of the cerebellum.

These clinical conditions make Paula a unique clinical case, because previously tested interventions are applied in similar populations with developmental dyslexia, and can be useful for verification or adaptation and even generate novel treatment proposals with solid scientific basis.

Instrument

To carry out this study, which seeks to relate executive functioning and phonological dyslexia, different psychological tests have been used, namely:

a. BANETA: this neuropsychological battery is composed of 41 tests that evaluate attention, phonological processing, repetition, comprehension, grammar, reading, dictation, arithmetic, perception, short and long term memory and working memory. It applies to boys and girls from 7 to 12 years old. For this case, only the subtests corresponding to the phonological processing scale will be used: phonological discrimination, word segmentation, phonological categorization, phoneme synthesis and word analysis. The instrument was used in three moments: (a) Initial condition A, diagnosis and baseline; (b) Condition B, follow-up and post-intervention measurement; and (c) Follow-up and measurement with withdrawal of the intervention process applied during stage B.

b. Stroop test: It is a neuropsychological test that evaluates the attentional capacity, especially the phenomenon called interference, closely linked to inhibitory processes, associated with executive functioning. This test has been applied as a support to the diagnosis of dyslexia in patient Paula and has been used in three different moments: (a) Initial condition A, diagnosis and baseline; (b) Condition B, follow-up and measurement post-intervention; and (c) Monitoring and measurement with withdrawal of the intervention process applied during stage B.

c. d2 Attention test: it is a neuropsychological test that measures the selective attention and mental concentration of the evaluated. This is achieved by measuring three components: (a) Working speed, (b) Working quality and (c) Accuracy. This test was applied with the purpose of measuring attentional capacities in three moments: (a) Initial condition A, diagnosis and baseline; (b) Condition B, follow-up and post-intervention measurement; and (c) Follow-up and measurement with withdrawal of the intervention process applied during the stage.

Procedure

This research has been carried out through a systematic process of intervention and evaluation out in various stages:

a. Diagnosis: in this stage the participant was evaluated and diagnosed, allowing her selection as a subject for this study.

b. Baseline setting and continuous measurements: once the diagnosis of developmental dyslexia has been made in the participant and its subsequent selection, the baseline measurement is carried out with the BANETA, Stroop and d2 tests, with the purpose of establishing parameters to contrast the possible effects of the treatment administered; this will be the first phase A. The measurements after the establishment of the baseline will be carried out every 30 days in phase B. This phase will last 120 days, which will apply a specialized intervention. Subsequently, the specialized intervention corresponding to the second phase A, with a duration of 30 days, during which two measurements will be made at intervals of 15 days.

c. Intervention: once the baseline has been established with the scores obtained in the different tests, the intervention is carried out. In this case, a treatment will be carried out based on the general scheme carried out by Cuetos and Vega (2010): rehabilitation of perceptual processes, rehabilitation of lexical processes, rehabilitation of syntactic processes, rehabilitation of semantic processes. The intervention will be carried out over a period of four months in one session a week.

d. Once the systematic interventions and measurements have been completed, the results are analyzed. The baseline was obtained when making the diagnosis.

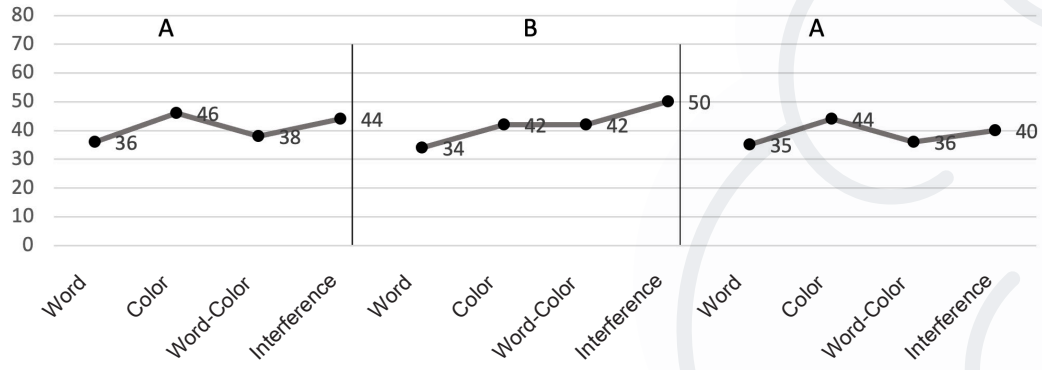
Measurements in phase B and second phase A are obtained in repeated applications. Phase B every 30 days in a period of 4 months and phase A every 15 days in a period of 1 month; therefore, the average scores for each phase will be estimated and will be presented in the figures of each test. The analysis will be carried out through the observation of the behavior of the figures according to each phase and each test.

Results

The results for the experimental conditions type ABA in the Stroop test of patient Paula are presented below. The observed data are typical scores (T) in the tasks of Word (P), Color (C), Word-Color (PC) and Interference (Interf). The high predictive interference score is significantly improved during the intervention.

Figure 2

Stroop test.

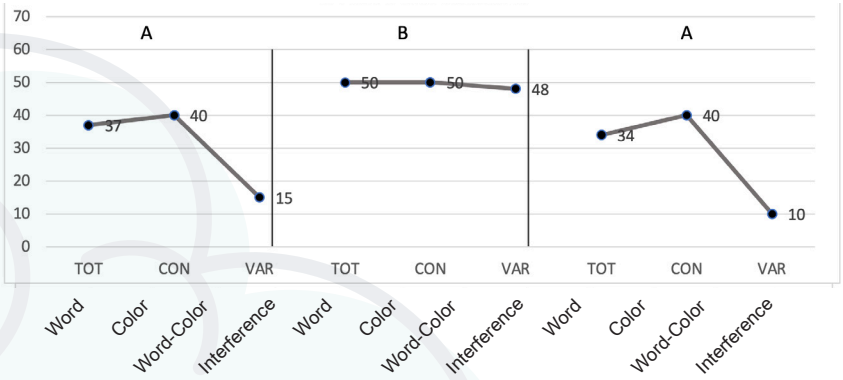


Source: own elaboration.

Also, the results for the experimental conditions type ABA in the d2 Test of Attention of the patient Paula follow. The observed data are typical scores (T) for Total Test Effectiveness (TOT), Concentration Index (CON), and Rate of Variation (VAR). All index scores improve significantly during the intervention, phase B. The TOT score of great experimental value reflects the impact of treatment.

Figure 3

d2 Attention test.



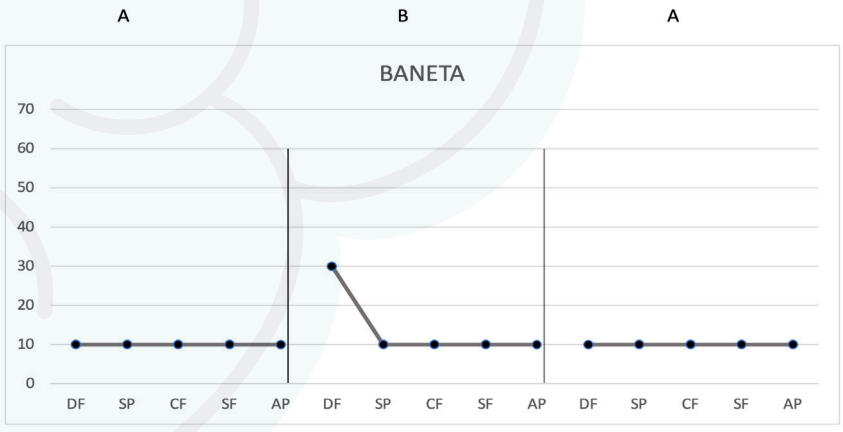
Source: own elaboration.

In sequence, the results for the experimental conditions type ABA in the BANETA test. The acronyms shown are for the following subtests: Phonological Discrimination (DF), Word Segmentation (SP), Phonological Categorization (CF), Phonem Synthesis (SF) and Word Analysis (AP).

The scores analyzed through the BANETA are presented in percentiles (Pc). The DF score is the only one that presents a significant variation and does so during the intervention process, phase B.

Figure 4

Experimental conditions type ABA in the BANETA test.



Source: own elaboration.

Discussion

The results obtained by the different psychological tests show significant improvements in the periods of intervention compared to the periods of withdrawal of treatment. In this regard, in the Stroop test, the patient presents values in the first condition, phase A, pretreatment: P = 36, C = 46, PC = 38 and Interf = 44. While in condition B, during treatment, they manifest in a more stable way (except in P): P=34, C=42, PC=42 and Interf=50. When the intervention was withdrawn, in the second phase A, the scores are plotted in a similar way to the pre-treatment period: P=35, C=44, PC=36 and Interf=40.

In all scenarios the P score is always low, this score evaluates, among many things, the reading speed, which, in this case, must be automatic and that in many children with language problems is manifested below the average, something that, as mentioned above, it is not modified even in phase B. However, during this phase, C scores fall four points from the first phase A, but a plateau between C and PC is observed in the treatment period, which could mean that intervention in phonological processes (perceptual rehabilitation) they improve the speed and capacity of naming and inhibition of stimuli, in a slightly more efficient phonological discrimination.

This is contrasted with the Interf. score in phase B six points are raised, taking into account that Interf. it evaluates among so many variables, the way in which a subject responds cognitively on demand, something typical of the executive function, indicating again that under the treatment described the executive functioning improves its flexibility and performance. The improvements are reversed when the treatment is withdrawn and oscillate in a similar way as in the first phase A. This is comparable to the results that other researchers have found (Barbosa *et al.*, 2019; Helland and Asbjørnsen, 2000; Varvara *et al.*, 2014), where the executive function is functionally deficient in children with language problems, such as dyslexia, with respect to their healthy counterparts.

In relation to the scores in the d2 Attention Test, the scores behave in a very similar way as in the Stroop. In the first phase A, pretreatment: TOT=37, CON=40 and VAR=15. In phase B, during treatment: TOT=50, CON=50 and VAR=48. In Phase II A, Withdrawal from Treatment: TOT=34, CON=40 and VAR=10. Considering this, it should be noted that the TOT score of the patient Paula, presents a particularity that can be associated

with the treatment. To do this, it will be necessary to take into account that TOT is the main measure of the D2 test and the most used in the experimental analysis, it measures the attentional control, inhibition of responses and the speed and precision of said control, rather, attention as a transversal cognitive process but the main one of executive functioning.

In this sense, Paula obtained a score in TOT pretreatment and posttreatment below the average, specifically two standard deviations below and in the average range while the intervention was applied. It can be deduced that the interventions performed to improve phonological processing directly affect the selective attentional ability and, in general, most of the processed stimuli have a significant symbolic charge that requires coding and decoding. This is a function directly related to the phonological process, therefore, it is stated that any action that improves the process of discrimination and inhibition of stimuli that increases the speed and accuracy of responses that improve phonological processing and executive function in children with dyslexia, in a cycle that could be classified as positive feedback.

Selective attention is understood as another aspect of the perception process (Treisman, 1969) and, therefore, regulates voluntary responses according to the activities that demand executive function. Therefore, it is valid to affirm that improving attentional processes is directly proportional to the improvement in phonological processing in children with dyslexia. In relation to the scores CON and VAR, they show better performance in phase B, which can be supported by the improvements in the TOT scores, because these scores, although not derived directly from this, are influenced by the degree of success in the test.

With regard to the BANETA scores, in the first phase A, pretreatment, the patient obtained the following scores: DF=10, SP=10, CF=10, SF=10 and AP=10. In phase B, during treatment: DF=30, SP=10, CF=10, SF=10 and AP=10. In the second phase A, withdrawal from treatment DF=10, SP=10, CF=10, SF=10 and AP=10. In this test the scores are diametrically different, otherwise they all behave the same in the different phases except for the DF scale, which stands at the 30 percentile in phase B and falls to its initial score of 10 in the second phase A. The DF scale measures the ability of the individual to perceptually identify words that, in this case, are presented in pairs, sometimes equal and other different, the same that improves in the patient during the intervention, probably related to the one that focuses on the rehabilitation of perceptual processes.

It is plausible to state that the positive changes in the DF scale are directly related to the treatment Paula has received. However, BANETA measured something beyond phonological discrimination of words, this was used to measure auditory processing (SP, CF, SF and AP) related to the syntax and semantics of language, which did not improve in any of the phases of experimentation. In this sense, it is valid to consider that the interventions (lexical, syntactic and semantic) did not alleviate these deficits too much. Accordingly, they did not have a positive effect on minimizing the patient's ability to have specialized hearing discrimination, so the problems were maintained independently at the study stages.

This, too, allows us to discuss the possibility that functional systems are separated and, at the same time, interconnected by mechanisms that are not yet clearly defined and that merit specific treatments. Some studies (Maassen *et al.*, 2001; Masterson *et al.*, 1995; Paul *et al.* 2006; Temple, 2002), likewise, have found that phonological processing as such and auditory processing do not manifest in a homogeneous or comparable way, being the deficit in auditory perceptual processing (syntactic and semantic) a basic condition in reading problems and writing of children with dyslexia, therefore, a strong variable against the application of treatments that seek the rehabilitation of these functions.

In relation with above, it is important to consider the neurological condition of Paula, who not only has abnormal waves, but also presents a mega cisterna magna in the cerebellum. Although these abnormalities do not manifest symptoms or syndromes (seizures or epilepsy), they can be strong variables that play against treatment and, at the same time, can be predictors in the development of other psychopathologies. Research has associated abnormalities in cerebellum regions with language problems in children with dyslexia (Nicolson *et al.*, 2001a, 2001b; Nicolson and Fawcett, 2005; Rae *et al.*, 2002; Stoodley, 2016; Stoodley and Stein, 2011, 2013), especially those related to the speed and accuracy of reading, writing and motor skills (graphesthesia), without this correcting the deficit theory of phonological processing.

However, the ways in which the cerebellar abnormality acts in Paula and her learning problems are unknown, this is because more measuring instruments such as functional neuroimaging techniques or positron emission would be needed. What is possible to assure by the results, is that these abnormalities have hindered the impact with which the patient has responded to the treatment, but how can this be verifiable?

None of the intervention activities acted directly on the speed and accuracy of written language processing, the speed and motor accuracy associated with writing, and the stimulation of other higher cognitive functions related to abnormalities found at the level of the cerebellum. In addition, the interventions carried out were developed within the framework of the theory of phonological processing, so, most of the sessions focused on the formation of mental representations of language and the acquisition of its basic structures.

In this sense, this study suggests two conclusions: (A) Children with dyslexia have an impoverished executive function, so any intervention that aims to improve perceptual processing, especially stimulus discrimination, will have a positive impact on attention and, therefore, executive performance will increase in a positive feedback loop; and (b) the improvement of executive functions by neuropsychological interventions in these areas partially improve phonological processing in children with dyslexia, because the stimulation of higher cognitive processes is related to the formation of the system of representations related to language, so that, executive and phonological functioning can be considered as parallel systems.

Finally, it is advisable in future research to consider the time factor, for example, to have more weekly sessions with the patient and, if possible, with at least six months of intervention instead of four. Similarly, a second condition B should be considered, which in this case was not possible for reasons related to the desire of his parents not to discontinue treatment too long. It should also be noted that interventions applied to children with dyslexia should contain activities that stimulate other higher cognitive processes such as working memory, long-term memory, information retrieval, speed of visual processing, motor skills, among others, and other factors. and not just focus on traditional intervention techniques. Executive function is impoverished in children with dyslexia and, therefore, its systematic measurement throughout the treatment process becomes a strong predictor of its effectiveness.

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Psychological impacts of COVID-19 confinement and social isolation on preschoolers in the San Salvador area

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SUMMARY

The COVID-19 pandemic, decreed in 2020 by the World Health Organization (WHO), motivated several countries and their governments to establish quarantine periods involving confinement and social isolation measures. These actions involved the suspension of educational services, including preschoolers, those who stopped having interactions with their peers and were forced to change their life routines. The objective of this study is to establish the psychological impacts of confinement and social isolation in preschoolers. A quantitative approach with non-experimental design was used. A sample of 10 boys and girls was selected, divided into two groups of equal proportion; the eligibility criteria for including infants in the sample were based on two factors: their preschool age and whether or not they exhibited behavioral problems. Parents were asked to verify the 3 to 6-year-old SENA, from which typical scores, representing the measurement variable, were obtained. Scores were analyzed with the t-student statistic and it was found that preschoolers with behavioral problems scored statistically lower than their healthy counterparts in the Personal Resources Index and the Emotional Intelligence scale. These were likely to worsen in those areas or were deficiencies that became apparent to their parents during that period. Independently, these participants, despite their deficits, managed to avoid the increase or appearance of new psychopathological behaviors, generating greater resilience and adopting more functional coping strategies.

Keywords: COVID-19, preschool, confinement and isolation, psychological impact, El Salvador.

Introduction

On December 2019 in the city of Wuhan, China, a disease of unknown etiology was detected that generated pneumonia and subsequent death in those who suffered from it. The first patients admitted to the hospitals came from the market of fish and live unprocessed animals in Hubei province, so the Chinese authorities encouraged all their scientific efforts to learn about the disease, finding as a cause a virus alien to the human being. It is still hypothesized that, due to the demand for meat in the Hubei market, sellers traded many species of animals (from snakes to bats), prepared in many forms, unprocessed and unhygienic, which is why a virus, previously unknown, would have been found to be in the market, "it jumps" from one species to another until it reaches humans in a process called zoonoses. The scientists also observed that this new disease had a great ease of contagion between people, similar to previous epidemics such as SARS-CoV1 and MERS in 2003 and 2012 respectively. Finally, and after different investigations, it was found that the pathogen responsible was a coronavirus, which they called briefly as COVID-19.

On January 1, 2020, at the request of the World Health Organization (WHO), the government of China provided a report in which it stated that it had controlled the epidemic, using the same measures valid for severe respiratory infections, and did not consider limiting international travel. By 11 March 2020, and in the face of the rapid spread of the disease worldwide, WHO declared a pandemic state and suggested more rigid preventive measures to control the disease (WHO, 2020).

In El Salvador, measures to placate the advance of COVID-19 were taken since January 23, 2020, when the Ministry of Health by decree declared an emergency throughout the national territory; subsequently, on March 11, 2020, by Executive Decree, home quarantine was declared for 30 days throughout the national territory; between March 14 and 31, both the Legislative Assembly and other state bodies used decrees that restricted basic constitutional rights in order to protect the health of the population. Among these was the suspension of face-to-face classes for the entire educational system, from preschool to higher education, forcing institutions to reinvent themselves to meet the curricular needs of their students in a 100 % virtual way (FundaUngo, 2021). There was no specific date at that time that indicated to private educational institutions to resume classes in online mode, nor did there exist a streamming platform or any type of LMS (Learning Managment System) to impart

and evaluate knowledge, this was a process carried out by each institution, with no standardization. In the national system, the same platform was used and classes resumed virtually.

According to data from the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2021a), the COVID-19 pandemic affected the lives of around 1.6 billion schoolchildren in more than 190 countries. This organization has also reported (UNESCO, 2021c) that during 2020 an average of two-thirds of the school year was lost due to confinement and isolation measures as a result of COVID-19. These measures directly affected the lifestyles of 93 million children in early childhood and preschool education in more than 30 countries worldwide (UNESCO, 2021b).

However, although there are no standards on how to proceed with the pedagogical continuity of schoolchildren in virtual mode, there are always benefits in any way to continue with school life and its social interaction. The results of an investigation (Stites *et al.*, 2021) on American parents during the COVID-19 quarantine period revealed that 36.4 % were concerned about the socio-emotional development of their preschool children, about the loss of activities due to confinement measures and social isolation. However, the parents perceived that maintaining a social interaction with other children at a distance, through virtual classes, was beneficial for their children, associated with this the parents shared more time with them, which made it easier for them to emotionally to lock up due to the quarantine.

In this sense, it is clear the importance of social interaction between preschoolers on their activities in nurseries, schools, etc. This period of life and social interaction is the first step outside home and adaptation to a formal educational model, the preschool level has a significant place in the life process. Pre-school education is not only the foundation of education that people will receive throughout their lives but transcends by being part of the first experiences that will support the socio-emotional and cognitive development of children (Hammer *et al.*, 2018).

The preschool period comprises ages between the birth of the child and the age of six. Pre-school education is quite heterogeneous to define, ranging from nurseries where the care of children is projected while parents are absent, to more formal institutions, oriented to educational objectives in a way that serves as a transition between home and school; however, in general terms what is called preschool is an environment

of important behaviors for children, a scenario to experiment in terms of social, emotional, language, cognitive and academic development, among peers; in short, a whole ecological-behavioral system (Smith *et al.*, 1980).

In perspective, the preschool age would be the one where children quickly develop their social, cognitive and emotional skills accompanied by the school institutions that welcome them. During this stage of life, environmental factors such as family and school strongly shape the (neuro) development of children and their effects will transcend until adulthood, hence the importance of the deprivation of these components in the life of preschoolers. In this sense, it is evident that the COVID-19 quarantine, and all the social restrictions, have altered lifestyles and other social and family dynamics around preschoolers. It is valid to consider that there are negative effects on mental health or its development that probably did not exist before the health crisis, which should motivate an investigation, since it has been an exceptional situation, abrupt and prolonged.

A study (Wang *et al.*, 2020) carried out with adult population (n=1210) in China, at the beginning of the COVID-19 pandemic, and the implementation of social biosecurity measures, it found that 53.8 % of respondents reported having suffered moderate to severe negative psychological effects and implemented social restrictions. In addition, 13.8 % of respondents reported mild depression, 12.2 % moderate and 4.3 % severe or severe during that time and conditions. Also, 7.5 % of respondents reported suffering from mild anxiety, 20.4 % moderate anxiety and 8.4 % severe and extremely severe; finally, 24.1 % reported suffering from mild stress, 5.5 % moderate and 2.6 % severe and extremely severe stress during the health crisis and its restrictive social measures. In other similar research (Pandey *et al.*, 2020) conducted on 1395 adults between the ages of 18 and 73 for 21 days of confinement in India, imposed by the government, it was found that 30.5 % reported feeling depressed, 22.4 % reported feeling anxious, 10.8 % stressed, the latter being mild and moderate. However, some reported suffering from severe depression (1.7 %) and anxiety (2.2 %), only 0.7 % reported severe anxiety symptoms; finally, measurements were taken every week while the mandatory home quarantine lasted, finding a statistically higher incidence in depression, anxiety and stress than at the beginning of the crisis (depression 37.8 %, anxiety 26.6 %, stress 12.2 % $p < 0{,}001$).

The first international study with european population that investigated the effects of conditions of confinement and social isolation caused by the COVID-19 pandemic, and emotional and behavioral problems in children and adolescents between 1 and 19

years of age, found that between 15.3 % and 43 % of participants (n=5823) reported the onset or increase of emotional and behavioral problems; specifically, preschoolers from one to six years of age, who make up 2726 participants of the children, manifested anxiety (4.7 %), mood problems (7.8 %) and oppositional defiant behaviors (9.9 %) as a result of the social and family conditions that led to the pandemic (Schmidt *et al.*, 2021). In another similar study (Glynn *et al.*, 2021) carried out with 169 preschoolers it was found that since the beginning of the COVID-19 pandemic, children showed increases (between 18.9-47.9 %, μ=32.8 %) in tantrums, fights with other children, oppositional behavior, isolation and disobedience. In addition, the mothers of these children completed the questionnaire on the preschoolers' feelings, which facilitates the identification of children at risk of suffering depression, the questionnaire of family routines and the Scale of Depression Studies, to those who, after performing a bivariate correlation of the reported scores, indicate a significant association between few family routines and depressive symptoms in boys and girls ($r=-.027$, $p < 0.05$); in some cases, these results were observed accompanied by depressive symptoms on the part of their mothers ($r= 0.40$, $p < 0.01$) which generated a worsening in the emotional states of the preschoolers.

Another international study (Orgilés *et al.*, 2020) with 1,143 parents of Spanish and Italian children between the ages of 3 and 18 during the beginning of the COVID-19 quarantine, found that 85.7 % of parents perceived changes in the emotional state and behaviors of their children during the health crisis and their social biosecurity measures; the psychological-emotional symptoms more frequently reported by parents were difficulty concentrating (76.6 %), boredom (52 %), irritability (39 %), restlessness (38.8 %), nervousness (38 %), feelings of loneliness (31.3 %) and generalized concern (30.1 %); the parents of the spanish sample reported more symptoms than the italians. In the same vein, another study carried out on 1,480 children and adolescents between the ages of 3 and 18 in Italy, Spain and Portugal, found, based on the parents' report, that the study was carried out. One third of the children were more anxious and restless and more than 40% irritable; all children reported changes in mood, sleep and behavior (Francisco *et al.*, 2020).

Similar results were found in a study conducted in Bangladesh (Yeasmin *et al.*, 2020), in which 384 parents of children between the ages of 5 and 15 were surveyed, who reported that 43 % of the children had mental health disorders although not clinically significant (subumbral), depression μ=2.8, anxiety μ=2, and sleep disorder μ=1); 30.5

% had mild disorders (depression μ=8.9, anxiety μ=4.9, and sleep disorder μ=3); 19.3 % had moderate alterations (depression μ =15.9, anxiety μ =9.2 and sleep μ=6) and 7.2 % had severe alterations (mean depression μ=25.2, anxiety μ=13.4 and sleep disorder μ=8); The scores of the children were divided into four groups: Subthreshold, mild, moderate and severe alteration, finding significant differences in scores of depression, anxiety and sleep disorders among the four groups using the Chi-square test. In the same vein, a comparative study with Italian, Spanish and Portuguese children between 3 and 18 years old, during the confinement for COVID-19, surveyed their parents, including children. Which reported that 38.1 % of children presented symptoms of anxiety and 19 % of depression during the application of restrictive social measures; In addition, the comparative analysis with Chi-square ($\chi 2 = 26.56$, $p < 0{,}001$, Cramer V = 0.22) revealed that Spanish boys and girls (56 %) scored more on the cutoff than their Italian counterparts (34.1 %) and Portuguese (8.5 %) on the anxiety scale, happening the same phenomenon with the depression scale ($\chi 2 = 13.40$, $p \leq 0{,}001$, Cramer V = 0.16) where Spanish children score higher (26.4 %) than their Italian (19.8 %) and Portuguese (26.5 %) counterparts, (Orgilés *et al.*, 2021).

Another investigation, carried out in Australia, found that during the time of confinement and the application of health recommendations to avoid contagion by COVID-19, preschoolers from the ages of three to five developed an increase in generalized fears at a cognitive level, probably associated with ideas of vulnerability, misconceptions about the risks of transmission of the virus, in addition, they developed concerns that the lifestyle changes necessary at that time (visiting grandparents, attending school) were permanent; at the behavioral level, aggressive behaviors, insomnia, difficulty regulating emotions, separation anxiety, and regressions of milestones previously reached (stop using the bathroom) increased; lastly, preschoolers showed gaming and drawing tendencies related to the illustrated or dramatic reproduction of social isolation, hospitalizations and deaths due to the virus, and their concerns about contagion (Vasileva *et al.*, 2021).

Similarly, an investigation was conducted (Arslan *et al.*, 2021) in Turkey where parents of preschoolers (n=287) were interviewed between the ages of three and six, finding that, during the time of confinement, children participated in more family activities although they included topics related to viruses, contagion, and others; while increasing introverted and aggressive behaviors. Also, screen time (tablet or smartphone) was prolonged due to the need of online classes and restrictions on outdoor activities.

In addition, although the parents did not report clinically significant changes in the children's play, they did notice that they revolved around anxieties regarding the pandemic, diseases, viruses among others, to this was added the repetitive adoption of role-play with characters such as doctors, nurses, and health care workers.

The above corresponds to a study carried out by Loades *et al.* (2020), who after conducting a review of research related to the mental health of children and adolescents facing the isolation and loneliness caused by the restrictive health measures implemented by COVID-19, he found that these types of measures lead boys and girls to an increase in stress levels, similar to those experienced in post-traumatic stress disorder; in addition, they show depressive symptoms, anxiety, unsafe attachments and even irritability and fear during that period.

From other perspectives and adding to the understanding of the psychological effects of health measures for COVID-19 in preschool children, a comparative study was carried out (Cantiani *et al.*, 2021), where investigated the effects of confinement in Italian children with healthy neurodevelopment compared to others with autism spectrum disorder (ASD) or any other problem from neurodevelopment: it was discovered that the emotional and behavioral problems caused by social isolation and confinement were no more pronounced for the last, so the psychological effects caused by COVID-19 confinement affect all children in a very similar way. However, it was found that the pre-existence of behavioral and emotional problems are a predictive factor if it is an increase of these in stressful situations and vulnerability, such as those that occurred during the pandemic. Another similar research (Amorim *et al*., 2020) carried out with 43 parents of children diagnosed with ASD in Portugal, found, from what was reported by parents, that children with ASD showed negative changes in their behavior due to social confinement in regards to biosecurity measures: most of them presented increases in anxiety, irritability, obsessive behaviors, hostility and compulsivity with respect to healthy controls (n=56); in addition, it was noted that routine maintenance during this period mitigated the negative effects of isolation.

Although, conducted with another type of clinical population, the effects of COVID-19 confinement and quarantine are similar, hence a study (Zhang *et al.*, 2020) conducted on 241 parents of children diagnosed with attention deficit hyperactivity disorder (ADHD) investigated the effects of confinement and social isolation during

the COVID-19 outbreak in China: it was found in the reports of parents who had an exacerbation of ADHD behaviors during confinement, also, relationship between acute stress manifested by infants, hours of study and emotional state of their parents as predictors of the increase in clinical behaviors.

The research results prove to be quite rich and heterogeneous; however, they have two common denominators. Quarantine conditions have adverse effects on both, healthy children, and those with behavioral-emotional or neurodevelopmental problems, the latter being more vulnerable in the worsening of their symptoms or disruptive behaviors. In addition, not only are there behavioral or emotional impairments in preschoolers during confinement and isolation, due to quarantine, but they are changing their perceptions of the world around them, sometimes to understand what is happening or, on the contrary, they are changing their perceptions of the world around them. They demonstrate difficulties in emotionally processing what they experience. In relation to this, a study (Idoiaga *et al.*, 2020), in a Spanish population, consisted on knowing the social representations about COVID-19 and the confinement of preschool children, finding that in infants between two and five years old they perceived coronavirus as an enemy that was defeated by staying at home. However, children have felt fear, nervousness and sadness, created by the health crisis, while experiencing other conflicting emotions such as feeling bored, overwhelmed and even angry about staying at home without being able to go out, or happy to spend at home with their family.

In retrospect, it can be observed how the school context and, mainly, the family and its dynamics, play an important role in preschoolers, exerting a strong influence on their lifestyles and mental health, which can be altered by critical episodes.

The described above is evidenced in a publication (Daks *et al.*, 2020) that combined contextual behavioral theory, the theory of family systems and cognitive flexibility in american parents (n=742) and the impacts of the COVID-19 pandemic. This study found that the cognitive flexibility of parents affects the family ecological system and causes negative symptoms in all members of it, including those who can generate chronic stress; whereas in affected children, feelings of anguish and depression are generated, mainly presenting problems of attention and aggressiveness; meanwhile, greater parental cognitive flexibility was related to family functioning that generates well-being for its members and serves as a reference model for resilience to life difficulties.

Furthermore, a similar occurrence was observed in a separate study conducted by Gassmam-Pines *et al.,* (2020) that evaluated the psychological well-being of families (n=561) in relation to the effects of health restrictions before and after the COVID-19 pandemic. It was shown that prior to these measures, the number of working parents decreased significantly from 67.9 % to 43.8 % ($p < .001$), generating also a decrease in psychological well-being in parents (depression, low sleep quality) that influenced the manifestation of behavioral difficulties in their sons and daughters under five years, lack of cooperation and recurrent states of concern.

The consequences of changes in family dynamics are heterogeneous and can become real dangers for preschoolers and other vulnerable family members. The pandemic brought many families to levels of tension and disruption similar to those that occurred in other types of disasters or wars. A research in the United States (Lawson *et al.*, 2020) confirmed that at least 89 % of children in the families participating in the study (n=342) were victims of abuse during the period of confinement ($X (12) = 218.9$, $p < .001$); in addition, the loss of parental work ($B=1.58$, $SE=.72$, $p =.03$), depressive parental symptomatology ($B=0.05$, $SE = .02$, $p < .01$), parental history of abuse ($B=4.72$, $SE = .70$, $p < .001$) and child gender ($B=74$, $SE = .32$, $p = .0.02$) were predictors of child abuse during confinement.

There are many known effects on preschoolers on confinement and social isolation due to the quarantine caused by COVD-19, from those internalized to those from the family system and its dynamics. This raises questions: is it necessary to conduct similar research in the Salvadoran context? and what could a study like this contribute to the set of findings that already exist? First, the findings of other research are not complete, it has limitations and have been carried out in foreign populations, which, although this does not detract from their absolute importance, their attempts at generalization are not 100 % comparable to our social, family and individual reality. Therefore, it becomes a need to investigate to establish the effects the effects that confinement and isolation by COVID-19 has had on Salvadoran preschool children. Specifically, a comparative study that can contrast measurements in patients with behavioral difficulties and their healthy counterparts, this from the application of standardized psychometric tests to their parents. In other words, the question is: is there a relationship between restrictive measures of confinement and social isolation due to the COVID-19 quarantine of 2020, in the appearance or increase of psychopathological behaviors in preschoolers with previously diagnosed behavioral

problems? Therefore, the main objective of this study is to demonstrate that the confinement and social isolation due to the quarantine psychologically impacted children with behavioral problems.

Therefore, behavioral problems will be considered those conditions contended in the SENA Scale, which can be divided into: internalized problems (depression, anxiety, social anxiety, and somatic complaints) and externalized (attention problems, hyperactivity-impulsivity, anger management problems, aggression, and defiant behavior).

This would be the first research using standardized psychometric tests to explore the manifestation of the phenomenon in the national context, serving as a basis for future research and interventions that help to avoid the effects of the pandemic and its restrictions on preschool children. Finally, conducting this type of study responds to the scientific need to know the effects and mechanism associated with the behavioral and emotional problems manifested by schoolchildren during the COVID-19 crisis and propose health intervention and prevention projects.

Method

Design

Due to the above effects of confinement and isolation caused by COVID-19 that affected preschoolers, specifically, generating psychological problems that did not exist before or exacerbating them, this study was carried out using the Children and Adolescents Evaluation System as a measuring instrument (SENA Infantil Family from 3 to six 6 old); a self-report form completed by the parents, in order to find the relationship between the two variables mentioned. Many preschool children have experienced the onset or exacerbation of clinical symptoms at the cognitive, emotional and behavioral level, related to the measures taken by governments and families due to the COVID-19 health crisis.

In this sense, the most appropriate methodological design for the measurement and analysis of the variables proposed by this study is: non-experimental correlational-causal transactional design (Hernandez-Sampieri *et al.*, 2006). This type of research design responds to the nature of the study variables, since it is not possible a

complete manipulation of them, in addition the way of obtaining the population sample, as well as the control of other variables indicated as intervening is less rigorous and, in the case of the sample, it is intentional, that is, the experimenter selects the participants in a non-probabilistic way, according to criteria that in their knowledge are important to properly carry out the study. It is transactional, since the measurement is taken in a specific section of the research time, it is a single take that involves all the participants, being the experimenter who considers the time and place to make the measurements, always safeguarding the scientific rigor that is allowed. Finally, it is considered that this study is correlational-causal, because the results obtained, although quantifiable cannot be attributed decisively to a variable sufficiently specific to ensure causality, because the research lacks a probabilistic sample and rigor in the control and manipulation of the study variables, related to the subjects of study as others considered intervening. It is limited to describing the relationship between restrictive measures of confinement and social isolation and the increases or appearance of psychopathological behaviors measured through the SENA completed by one of the parents of preschoolers, usually the one who lives with it for the longest time. Nevertheless, this does not detract from the credibility or validity of the findings, it only demonstrates scientific creativity, since it wisely considers that not all phenomena, however fascinating they may seem, can be replicated in a laboratory, being this flexibility an appropriate characteristic of science that studies the psychological nature of the human being.

Given the above considerations and in the spirit of investigating the psychological effects of the pandemic in preschool children, the variables that constitute the object of study are divided into independent and dependent, the first being that which is controlled by the researcher. In this case, due to the characteristics of the phenomenon of measurement, the independent variable cannot be manipulated or applied to the participants, however, it can be found in the subjects as an inherent property to them (Hernandez-Sampieri and Mendoza, 2018). Therefore, in this order of ideas, the independent variable of this experiment has two levels and one level for its dependent variable.

Independent variable:

Level 1: parents of preschoolers whose children experienced confinement and social isolation due to the COVID-19 quarantine and report behavioral problems and deterioration.

Level 2: parents of preschoolers childrens that experienced confinement and social isolation due to the COVID-19 quarantine and whose do not report behavioral problems but that report a behavioral worse.

Dependent variable: critical T scores in the SENA Infantile Family test from 3 to six 6.

Hence, the research teams are categorized into experimental and control groups. The experimental group is composed of parents and preschoolers who felt the social restrictions of restrictions of home quarantine, and infants where previously diagnosed with behavioral problems. For the purposes of this study and considering the access to the participants of the sample, the behavioral problems diagnosed in pedriatic pacients, those conceptualized as internalized and externalized are considered. The control group is its counterpart, composed of parents of children who had similar life experiences due to home quarantine, but whose preschoolers do not have diagnosed behavioral difficulties. It is imperative to clarify that the reception of data and scores was made from the application of the SENA to one of the parents, the one who shared more time with the child.

Participants

The sample for this research is non-probabilistic, according to this, no equations are used for the selection of participants; however, it is considered that experimental subjects must have a minimum of criteria that makes them eligible participants, although the final selection is always up to the expert judgment of the researcher. The inclusion and exclusion criteria that participants must meet to be part of the experimental sample are as follows:

a. Parents between the ages of 18 and 35.
b. Parents with no history of psychological problems during the last year.
c. Indistinct marital status.
d. Academic level of parents: minimum 10 years of academic studies.
e. Boys and girls aged between 3 and 6 years.
f. Children with at least one year since a diagnosis of a behavioral problem was received: depression, anxiety, social anxiety, somatic complaints, attention problems, hyperactivity-impulsivity, anger management problems, aggression and challenging behaviors.
g. Children without diagnosis of neurodevelopmental disorders.

h. Not having experienced psychotic symptoms or episodes of epilepsy.
i. Being on psychopharmacological treatment (only if prescribed).
j. Parents should not have a history of substance abuse.
k. Parents should not possess chronic physical diseases.

As for the control group, subjects who do not present behavioral-emotional problems must meet the following criteria to be part of a control sample:

a. Parents between the ages of 18 and 35.
b. Parents with no history of psychological problems during the last year.
c. Indistinct marital status.
d. Academic level: minimum 10 years of academic studies.
e. Boys and girls between 3 and 6 years old.
f. Children without diagnosis behavioral problem or neurodevelopmental disorders.
g. Not having experienced psychotic symptoms or episodes of epilepsy.
h. Not being in psychopharmacological treatment.
i. Parents should not have a history of substance abuse.
j. Parents should not possess chronic physical diseases.

As a general criterion, for each preschoolers, only one parent will be selected, who reports a greater number of hours of companionship with the child. Five parents and one child will be chosen for each of them, who manifest behavioral/emotional problems and 5 parents and one child for each without any clinical manifestation. The aim is to balance the sex in proportion to the number of infants; 3 boys and 2 girls for each group of participants. The technique for the selection of participants will be made by snowball sampling. This type of non-probabilistic sampling technique consists of relying on the criteria of the participants to refer others that they consider to meet the selection requirements and thus be part of the study.

Instruments

To carry out the study, measurements will be made through the Evaluation System for Children and Adolescents (SENA) of TEA Ediciones, which is an instrument that evaluates a wide spectrum of emotional and behavioral problems: this has three different levels of the evaluated person: infant from 3 to 6 years old; primary from 6 to 12 years old; secondary from 12 to 18 years old. The test evaluates from 3 to 18 years old. These levels are divided according to who applies: family (parents), school (teachers)

and self-report (assessed). Only for the child level there are the family and school levels. All scores are expressed in T with age scales. In addition, the Beck Depression Inventory and Beck Anxiety Inventory will be used to evaluate parents and rule out any clinical symptoms that occurred during the last three months.

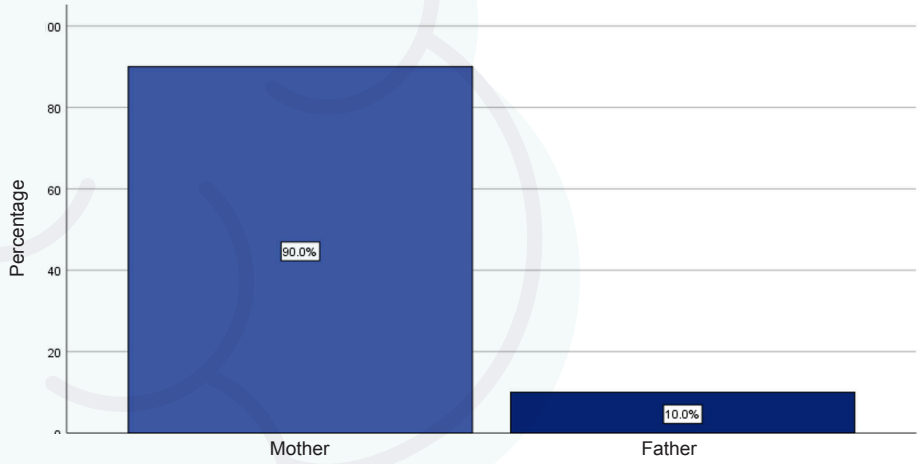
Finally, a brief survey is applied on parents to know their opinion regarding the possible behavioral changes that may or may not have observed in their children during the period of health crisis and to relate the information.

Results

For the study, 10 parents with preschool children participated, who completed the SENA Infantil Family questionnaire from 3 to 6 years old. 90 % of the informants were mothers and only 10 % were fathers, as shown in Figure 1. There were no informants whose relationship with the children were: grandparents, caregivers or legal guardians.

Figure 1

Percentage of respondents who completed the questionnaire.

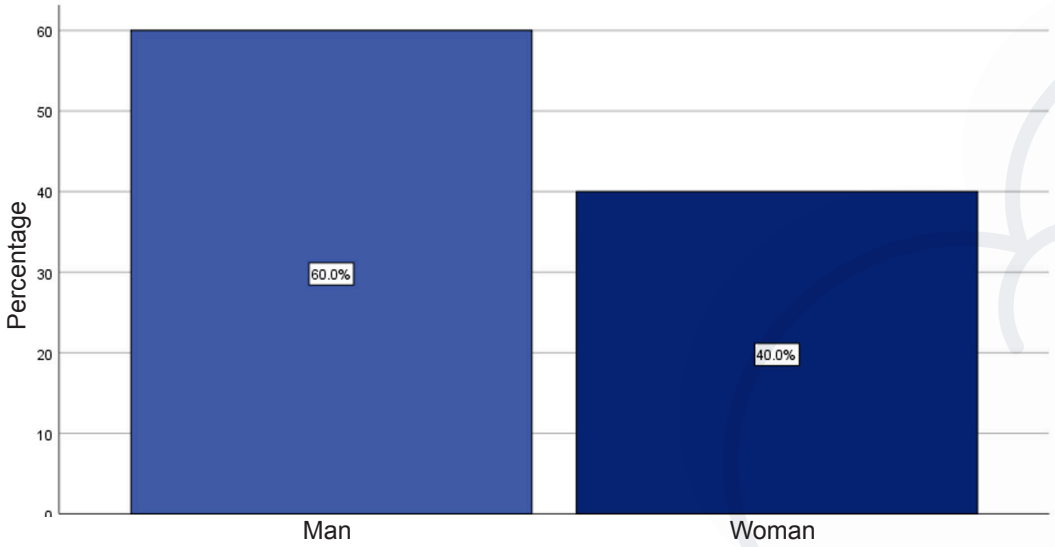


Note: percentages in relation to valid questionnaires received at the date of data receipt.
Source: own elaboration.

As for children, it was reported a total participation of 4 girls and 6 boys. Boys represent a total of 60 % and girls and 40 % of the sample, as shown in Figure 2. The age of the boys and girls ranged from 4 to 6 years of age, specifically 80 % of the sample was four years old and only 20 % were six years old (see Figure 3).

Figure 2

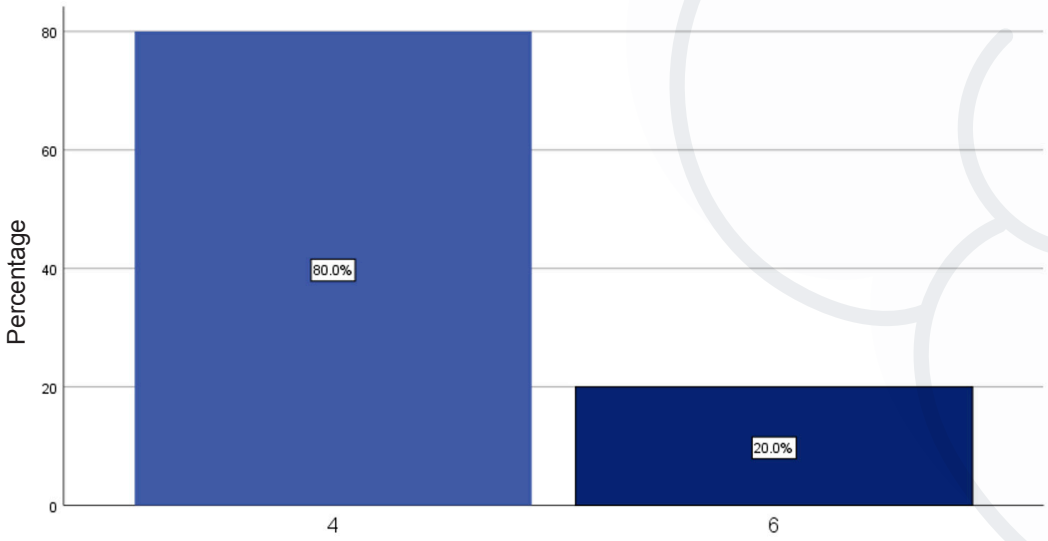
Percentage of children who participated in the study.



Note: in total 6 boys and 4 girls for a total of ten participants.
Source: own elaboration.

Figure 3

Age percentage of children in study.



Note: percentage of age in years completed.
Source: own elaboration.

Infants were distributed proportionally to the experimental and control groups as follows: 2 girls and 3 boys for each, for a total of 10 participants. To belong to the experimental group, it was necessary for parents to report that their children had been diagnosed with a behavioral problem mentioned above.

Table 1 presents the distribution of children according to their age and belonging to the experimental group or control; it is observed that the experimental group consists of two 6 year old boys and one 4 year old boy and three children: two 6 year old and one 4 year old, the girls are two and are 4 years old. This is not the case of the control group in which all children are 4 years old.

Table 1

Distribution and frequency of boys and girls to experimental group and control according to sex and age.

			Child age		Total
			4	6	
Yes	Sex of child	Man	1	2	3
		Woman	2	0	2
	Total		**3**	**2**	**5**
No	Sex of child	Man	3		3
		Woman	2		2
	Total		**5**		**5**

Note: the need for a psychological diagnosis to belong to the experimental group or not is used as a reference.
Source: own elaboration.

As for the diagnoses presented by the children belonging to the experimental group, only two children aged 6 years and one of 4 years of age present hyperactivity; in girls of the same group, one has anxiety and attention problems, for a total of five experimental infants. Children in the control group do not report behavioral problems diagnosed according to their parents.

Table 2

Distribution and frequency of children according to age and psychological diagnosis reported by parents.

Child age			Psychological diagnosis				Total
			None	Ansiety	Hyperactivity	Attention problems	
4	Sex of the child	Man	3	0	1	0	4
		Women	2	1	0	1	4
	Total		**5**	**1**	**1**	**1**	**8**
6	Sex of the child	Man			2		2
	Total			**2**		**2**	

Note: only two children are 6 years old at the age of study and belong to the experimental group.
Source: own elaboration.

For the inferential analysis of each of the populations, the Levene test for experimental control groups assumes equality in the variance of the sample for the global index scores of the SENA Infantil Family test from 3 to 6 years. The comparison of t-student means for independent samples does not show statistically significant differences in the scores of the scale GLO ($t=-1.01$, $p=0.33$), EMO ($t=1.05$. $p=0.32$), CON ($t=0.93$, $p=0.37$), EJE ($t=0.55$, $p=0.59$); experimental participants ($\mu=57.80$, $\sigma=14.95$; $\mu=58.60$, $\sigma=20.08$; $\mu=51.00$, $\sigma=10.95$; $\mu=61.60$, $\sigma=14.32$) get similar scores as healthy controls ($\mu=50.20$, $\sigma=7.43$; $\mu=49.00$, $\sigma=3.08$; $\mu=45.80$, $\sigma=5.89$; $\mu=57.40$, $\sigma=9.07$) in each measurement respectively. There are statistically significant differences in the Index REC ($t=-3.77$, $p=0.005$), experimental participants ($\mu=31.40$, $\sigma=6.87$) have fewer personal resources than healthy controls ($\mu=50.60$, $\sigma=9.04$), for both descriptions (see Tables 3 and 4).

Table 3

Mean and standard deviation of the global indices for each group of participants.

Have ever received a psychological or neurological diagnosis		N	Mean	Deviation
Global Problem Index (GLO)	Yes	5	57.80	14.957
	No	5	50.20	7.430
Emotional Problems Index (EMO)	Yes	5	58.60	20.082
	No	5	49.00	3.082
Behavioral Problems Index (NOC)	Yes	5	51.00	10.954
	No	5	45.80	5.891
Executive Function Problems Index (AXIS)	Yes	5	61.60	14.328
	No	5	57.40	9.072

Have ever received a psychological or neurological diagnosis		N	Mean	Deviation
Personal Resource Index (REC)	Yes	5	31.40	6.877
	No	5	50.60	9.044

Note: the distribution is made according to the inclusion criteria for each group of participants.
Source: own elaboration.

Table 4

t-Student test of the global indices for each group of participants.

Scale	Levene test of equality of variances		T-test for equality of means		
	F	Sig.	T	gl	Sig. (bilateral)
Global Problem Index (GLO)	6.045	.061	1.018	8	.339
Emotional Problems Index (EMO)	4.041	.079	1.057	8	.322
Behavioral Problems Index (NOC)	1.020	.342	.935	8	.377
Executive Function Problems Index (AXIS)	1.463	.261	.554	8	.595
Personal Resource Index (REC)	.270	.617	-3.779	8	.005*

Note: *statistically significant p-scores (p<0.05).
Source: own elaboration.

Levene's test for the control and experimental groups assumes equality in the sample variance for the internalized problem scores on the SENA Infantil Family test from 3 to 6 years of age. The comparison of t-student means for independent samples did not show statistically significant differences in the scores of the DEP scale (t=-1.46, p=0.18), ANS (t=-0.12. p=0.90), ASC (t=2.29, p=0.051), SOM (t=-0.49, p=0.63); experimental participants (μ=68.40, σ=24.86; μ=51.80, σ=17.52; μ=56.40, σ=11.12; μ=46.60, σ=8.76) score similar to healthy controls (μ=51.40, σ=7.36; μ=52.80, σ=5.58; μ=43.20, σ=6.41; μ=50.40, σ=14.87) for each measurement respectively (see Tables 5 and 6).

Table 5

Mean and standard deviation for "internalized problem" scales for each group of participants.

Have ever received a psychological or neurological diagnosis		N	Mean	Deviation
Depression (PED)	Yes	5	68.40	24.866
	No	5	51.40	7.369
Anxiety (ANS)	Yes	5	51.80	17.527
	No	5	52.80	5.586

Have ever received a psychological or neurological diagnosis		N	Mean	Deviation
Social anxiety (BSA)	Yes	5	56.40	11.127
	No	5	43.20	6.419
Somatic complaints (SOM)	Yes	5	46.60	8.764
	No	5	50.40	14.876

Note: the distribution is made according to the inclusion criteria for each group of participants.
Source: own elaboration.

Table 6

t-Student test for "internalized problem" scales for each group of participants.

Scale	Levene test of equality of variances		T-test for equality of means		
	F	Sig.	t	gl	Sig. (bilateral)
Depression	10.152	.185	1.466	8	.181
Anxiety	2.425	.158	-.122	8	.906
Social anxiety	.718	.421	2.298	8	.051
Somatic complaints	.470	.513	-.492	8	.636

Note: there are no statistically significant scores (p>0.05).
Source: own elaboration.

Levene's test for the control and experimental groups assumes equality in the variance of the sample for the externalizing problems scores on the SENA Infantil Family test from 3 to 6 years of age. The t-Student mean comparison for independent samples does not show statistically significant differences in the ATE scale scores (t=-0.77, p=0.46), HIP (t=- 071. p=0.49), IRA (t=0.32, p=0.75), AGR (t=1.95, p=0.08), DES (t=0.21, p=0.83); experimental participants (μ=63.80, σ=7.85; μ=45.20, σ=24.38; μ=51.20, σ=6.76; μ=51.60, σ=11.08; μ=49.60, σ=12.75) score similar to healthy controls (μ=59.00, σ=11.40; μ=54.40, σ=15.53; μ=50.00, σ=4.63; μ=41.80, σ=1.78; μ=48.00, σ=10.22) for each measurement respectively (see Tables 7 and 8).

Table 7

Mean and standard deviation for the "externalized problem" scales for each group of participants.

Have ever received a psychological or neurological diagnosis		N	Median	Deviation
Attention problems (ATE)	Yes	5	63.80	7.855
	No	5	59.00	11.402
Hiyperactivity (HIP)	Yes	5	45.20	24.386
	No	5	54.40	15.534
Anger management problems (IRAs)	Yes	5	51.20	6.760
	No	5	50.00	4.637
Aggression (AGR)	Yes	5	51.60	11.082
	No	5	41.80	1.789
Challengin behavior (DES)	Yes	5	49.60	12.759
	No	5	48.00	10.223

Note: the distribution is made according to the inclusion criteria for each group of participants.
Source: own elaboration.

Table 8

t-Student test for "externalized problem" scales for each group of participants.

Scale	Levene test of equality of variances		T-test for equality of means		
	F	Sig.	t	gl	Sig. (bilateral)
Attention problems	2.105	.185	.775	8	.461
Hyperactivity	.067	.802	-.711	8	.497
Anger management problems	.184	.679	.327	8	.752
Aggression	7.609	.475	1.952	8	.087
Challenging behavior	.004	.953	.219	8	.832

Note: there are no statistically significant scores (p>0.05).
Source: own elaboration.

The Levene test for the control and experimental groups assumes equality in sample variance for scores of other problems on the test SENA Infantil Family from 3 to six 6 old. The comparison of t-student means for independent samples did not show statistically significant differences in the scores of the RET scale (t=0,935, p=0.37), INU (t=-0.94. p=0.37); experimental participants (μ=63.80, σ=15.97; μ=70.20, σ=7.05) score similar to healthy controls (μ=54.60, σ=15.14; μ=59.20, σ=25.15) for each measurement respectively (see Tables 9 and 10).

Table 9

Mean and standard deviation for the scales "other problems" for each group of participants.

Have ever received a psychological or neurological diagnosis		N	Median	Desviation
Delay in development	Yes	5	63.80	15.975
	No	5	54.60	15.143
Unusual behavior	Yes	5	70.20	7.050
	No	5	59.20	25.154

Note: the distribution is made according to the inclusion criteria for each group of participants.
Source: own elaboration.

Table 10

t-Student test for "other problem" scales for each group of participants.

Scale	Levene test of equality of variances		T-test for equality of means		
	F	Sig.	t	gl	Sig. (bilateral)
Developmental delay (RET)	.388	.551	.935	8	.377
Unusual behavior INU)	2.917	.126	.942	8	.374

Note: there are no statistically significant scores (p>0.05).
Source: own elaboration.

The Levene test for the control and experimental groups assumes equality in the variance of the sample for the scores of vulnerability scales in the SENA Infantil Family test from 3 to six 6. The comparison of t-student means for independent samples does not show statistically significant differences in the scores of the scale REG (t=-0.14, p=0.89), RIG (t=1.59. p=0.15), AIS (t=2.16. p=0.06), APE (t=2.03. p=0.07); experimental participants (μ=52.60, σ=17.78; μ=66.00, σ=11.24; μ=74.20, σ=14.09; μ=67.40, σ=24.13) obtain scores similar to healthy controls (μ=53.80, σ=6.45; μ=55.60, σ=9.34; μ=53.40, σ=16.27; μ=45.20, σ=3.56) on each measurement respectively (see Tables 11 and 12).

Table 11

Mean and standard deviation for "vulnerability" scales for each group of participants.

Have ever received a psychological or neurological diagnosis		N	Median	Deviation
Emotional regulation problems (ERW)	Yes	5	52.60	17.785
	No	5	53.80	6.458
Stiffness (RIG)	Yes	5	66.00	11.247
	No	5	55.60	9.343
Insulation (AIS)	Yes	5	74.20	14.096
	No	5	53.40	16.273
Attachment difficulties PE)	Yes	5	67.40	24.131
	No	5	45.20	3.564

Note: the distribution is made according to the inclusion criteria for each group of participants.
Source: own elaboration.

Table 12

t-Student test for "vulnerability" scales for each group of participants.

Scale	Levene test of equality of variances		T-test for equality of means		
	F	Sig.	t	gl	Sig. (bilateral)
Emotional regulation problems	6.104	.459	-.142	8	.891
Stiffness	.286	.607	1.590	8	.150
Insulation	.058	.815	2.160	8	.063
Attachment difficulties	13.939	.006	2.035	8	.076
Challenging behavior	.004	.953	.219	8	.832

Note: there are no statistically significant scores (p>0.05).
Source: own elaboration.

The Levene test for the control and experimental groups assumes equality in the variance of the sample for the scores of personal resources scale in the SENA Infantil Family test from 3 to 6 years. The comparison of t-student means for independent samples does not show statistically differences significant scores on the SOC scale (t=-1.57, p=0.15); experimental participants (μ=36.40, σ=8.23) obtained similar scores as healthy controls (μ=46.20, σ=11.18). There are statistically significant differences in the emotional intelligence scale (t=0.96, p=0,001), experimental participants (μ=31.40, σ=7.89) have lower personal resources than healthy controls (μ=55.00, σ=7.58), for both descriptions see Tables 13 and 14.

Table 13

Mean and standard deviation for "personal resource" scales for each group of participants.

Have ever received a psychological or neurological diagnosis		N	Median	Deviation
Integration and social competence (SOC)	Yes	5	36.40	8.234
	No	5	46.20	11.189
Emotional Intelligence (EMI)	Yes	5	31.40	7.893
	No	5	55.00	7.583

Note: the distribution is made according to the inclusion criteria for each group of participants.
Source: own elaboration.

Table 14

t-Student test for "personal resource" scales for each group of participants.

Scale	Levene test of equality of variances		T-test for equality of means		
	F	Sig.	t	gl	Sig. (bilateral)
Integration and social competence		.261	-1.577	8	.153
Emotional Intelligence		**.966**	**-4.821**	**8**	**.001***

Note: *statistically significant p-scores (p<0.05).
Source: own elaboration.

Discussion

This study included a sample of 10 participants, preschool children and their respective parents (who answered the questionnaire SENA Infantil Family from 3 to 6 years old), all residents in San Salvador. The participants and their parents were divided into 2 groups of equal proportion being: 3 children and 2 girls with behavioral problems, who formed the experimental group; and 3 boys and 2 girls, in the control group. An inferential statistical analysis was performed, in this specific case, a comparison of means with t-Student test for independent samples for the typical scores obtained in the Child Family SENA from 3 to 6 years in each group of scales. It was found, based on what was reported by the parents in the SENA questionnaire, that children with behavioral problems have statistically lower scores in the Personal Resources Index (REC) and the Emotional Intelligence Scale (EMI) than their healthy control counterparts. For

all other indices and scales, no statistically significant differences were found between the 2 groups.

Before continuing with the analysis of the data obtained, the emotional intelligence will be conceptualized, whose definition is the ability to perceive, understand, regulate and adjust emotions in an adaptive way in itself and others (Mayer *et al.*, 1999; Salovey and Sluyter, 1997). In relations with above, together with the results obtained in IEM and REC, the statistical differences presented by the groups of children with behavioral problems not only show that they have fewer personal resources to coping demands of daily life and, in some cases, the crises that may exist in this and that, therefore, it is closely related to a deficit in the development of their emotional intelligence, but it shows that they are more vulnerable to stress in general and their capacity for psychosocial adaptation is compromised.

In this order of ideas, it should also be considered that the combination of these scores may be typical in this population, in this case, the suffering of some behavioral or psychological problem always leaves open the possibility that these subjects are more vulnerable, with less personal and coping resources than those of the same age without these conditions in their mental health (Beauchaine *et al.*, 2010; Merikangas *et al.*, 1999; Moreland and Dumas, 2008; Price and Zwolinski, 2010). The results of this study are contrasted with similar researches in children and adolescents (Esturgo-Deu and Sala-Roca, 2010; Poulou, 2014) indicate that suffering from behavioral problems worsens stress management and impairs the acquisition and implementation of more functional and adaptive interpersonal skills. The inherent interrelationship between the development of interpersonal skills and that of emotional intelligence cannot be ignored. Some research (Mavroveli *et al.*, 2009; Salavera *et al.*, 2019; Schutte *et al.*, 2001, 2002) have verified the previous interrelation between both components, so a positive development of these contribute to the better coping of the psychological demands that daily life demands and that impact on the quality of life.

In addition, children with behavioral problems have significant disadvantages to their healthy peers, may have a worse performance facing daily psychological demands and coping with crises, which increases the likelihood of causing an exacerbation or manifestation of new dysfunctional behaviors. This would generate a loop effect, where a lower capacity to resist stress, caused by the environment, would cause greater psychological dysfunction, which will decrease resistance to stress, causing

the system to feedback itself. As has been stated, it makes even more sense if one takes into account the biological model of stress exposed by various researchers (Dallman *et al.*, 2000; Smith and Vale, 2006; Tsigos and Chrousos, 2002), in which the hypothalamic-pituitary-adrenal (HPA) axis exerts control over the stress response, which feeds itself to reach homeostasis under normal conditions. It has been tested (Raison and Miller, 2003; Tofoli *et al.*, 2011; Tsigos and Chrousos, 2002) that a prolonged imbalance, cause or exacerbate psychopathological behaviors, driving a chronic character of the disorders.

Considering the above and the lack of emotional intelligence and personal resources of children with behavioral problems in this study, it is not difficult to consider the existence of a greater psychosocial vulnerability of preschoolers, which could translate into a lower capacity for resilience. Resilience is defined as the capacity for a desirable adaptation in the context of risk or adversities associated with extreme problems (earthquakes, kidnappings, psychological or sexual abuse) that may cause psychosocial dysfunction (Masten, 2011); therefore, having a diminished resilience capacity raises the risk to the negative impacts of stress caused by everyday problems and, especially, those experienced in crisis situations, such as the one caused by the COVID-19 quarantine of 2020, something that in healthy preschoolers has had less impact. All this also means that preschoolers with a diminished resilience capacity have ineffective or dysfunctional coping strategies to stress, compromising their adaptive or capacity adjustment. This reality has been observed by other researches (Garmezy *et al.*, 1984; Masten and Gewirtz, 2006; Rutter, 1981) those that have also shown that resilience is a capacity that develops, especially at early ages and whose importance, to be positive, results as a protective factor of mental health in adolescence and adulthood, preventing the development of psychopathological symptoms. In this sense, critical or traumatic situations in previously vulnerable subjects, such as those in this study, would only diminish the opportunity for the development of a more functional resilience.

However, the findings of this study could be opposite and interesting with respect to the previous theories and analysis described. The results show that children with behavioral problems did not worsen their condition during the home quarantine compared to the control group, contrary to any prognosis. This situation could have a grip in 2 probable scenarios considered by the author: (a) The effects of home quarantine and its other restrictive measures only further degraded the personal resources and emotional

intelligence of children with behavioral problems than their counterparts controlled, without affecting other areas of conduct; or (b) The personal resources and emotional intelligence deficit of children with behavioral problems, were a premorbid condition and, the crisis that meant the quarantine and its restrictive measures, did not worsen the same or other problems, but only made evident the deficit to their parents, which reported this by supplementing the SENA scale.

Regardless of the order in which this peculiar situation occurred and against theoretical and empirical forecasts, the scores in the SENA of children with behavioral problems did not show the appearance of new manifestations or exacerbations of psychopathological behavior statistically significant as reported by healthy controls. However, one thing could be clear is that the psychosocial crisis caused by the COVID-19 pandemic was a source of stress that pressured children with behavioral problems to make the necessary adjustments to cope better with this crisis psychologically. Although this could be considered positive, as it demonstrates the emergence or strengthening of resilience capacities, it cannot be ignored that there are several scales in which children with behavioral problems have higher average scores than their counterparts in the control group.

In relation to the above, it is evident that boys and girls with behavioral problems score on average higher in several global index such as GLO (μ=57.80), EMO (μ=58.60), CON (μ=51.00) and EJE (μ=61.60) than the boys and girls of the control group GLO (μ=50.20), EMO (μ=49.00), CON (μ=45.80) and EJE (μ=57.40). Although these, as detailed above, have no statistical significance, it makes clear that clinical symptomatic manifestations, in general, are on average higher in children with behavioral problems. The same is not true of some of the internalized problem scales, for example: ANS and SOM scores are higher on average in the control group than in the experimental group, as shown in Table 5. This combination seems congruent, since somatic complaints have as a source of anxious symptoms, although this does not mean that the children of the experimental group do not present in proportion these problems. In the other internalized problems, boys and girls with behavioral problems show higher averages in the scores, displaying again a little more difficulties than the boys and girls of the control group, although these differences do not have statistical significance. In the case of externalized problems and vulnerability, a similar case occurs with the HIP and REG scores (see Tables 7 and 11), in which the children of the control group score higher on average than the

experimental children, being again consistent scores, hyperactive behaviors can cause poor emotional regulation and vice versa.

These scores, which at first glance are not the subject of analysis, can be considered the beginning of an unexplored form of short or medium term consequences of psychological effects in crisis conditions on children without prior behavioral disorders. If so, they would raise a new series of questions about the subclinical psychological effects on the child population as a result of having experienced crises or traumas that significantly restricted their psychosocial development, in this case, the COVID-19 quarantine.

With all the above revised, there is no doubt that the quarantine for COVID-19, involved not only home confinement, but also measures such as social isolation, in that sense, restricting direct interpersonal contact with others, limiting itself for a long time through digital means, and limiting itself to other people, this being a vertiginous change in lifestyle, evidently a critical event, that generated high levels of stress, similar to those experienced in contexts of wars or natural disasters, as well as the health crisis of 2020, break with the continuity of the lifestyle and violate the integrity of the psychological core of the person. This fact affects children, who are in the development of their resilience capacities and coping strategies, weaving support networks and cognitively evolving toward a higher thinking that serves in favor of adequate psychological and social adaptation.

This study has tried to know and relate two elements: (a) The health crisis due to COVID-19 together with its restrictive measures, and (b) The psychological impact on preschoolers with and without behavioral problems during that period of time. The findings show the existence of the increase or maintenance of certain psychological problems in preschoolers who already suffered behavioral problems when the quarantine period was implemented, such as an impoverishment of personal resources and emotional intelligence. It also showed that these same preschoolers did not show an increase or appearance of new disruptive behaviors during that period, which is opposite to the findings of other similar research. In addition, the existence of subclinical symptoms in both groups of participants was known, which appeared during this period of time, although they are not statistically significant, should be the subject of future studies. With this background and as mentioned above, it is likely that preschoolers with behavioral problems only experienced a greater impoverishment

of their personal resources and emotional intelligence, or this was something already present and remained unchanged at the time of the health crisis, being the most striking the fact that these deficiencies, being so crucial for the proper functioning and adaptation to novel and critical situations, did not lead to the appearance or exacerbation of other psychopathological behaviors statistically significant against the participants of the control group, boys and girls without behavioral problems.

It is plausible to consider that both healthy preschoolers and those with behavioral problems, could have been influenced by protective factors that generated more adaptive coping forms to this crisis; in sum, they enhaced their resilience, which prevented the appearance or increase of psychopathological behaviors during that period of time. Given this, it is possible to consider new lines of research, aimed at finding the processes involved that have facilitated the development of greater resilience in the context of the health crisis due to COVID-19, accompanied by the implementation of restrictive measures at the social level. Likewise, it should be considered to explore the role of the parents in that historical moment for children and the different family dynamics that were generated and positively influenced in a better adaptation and psychological and emotional containment.

However, although the study in question is a pioneer in the country and its scientific findings are novel, it is important to consider some elements that may contribute to improving the replication of similar studies:

- It must be considered to carry out again an updated bibliographic review on the subject, specifying to find those closest to the context in which this study is being carried out. On this occasion, many recent papers have been found, although they are far from having developed in social and cultural contexts similar to this one. This turns out to be a theoretical and methodological impasse when making a research proposal and limits its approach, as well as the subsequent analysis of its findings.

- This research was conducted with a non-experimental correlational transactional design, strictly quantitative approach. This choice was made based on the theoretical orientation of the study as well as the facilities to access the sample, the instruments and data analysis. In itself, this is not a limitation, but it configures a way to study and understand the same phenomenon, so any other attempt, from another perspective, would contribute to the knowledge that has already been generated about it.

- A third consideration for future research is to guide the expansion of the study sample through a greater specification of the inclusion and exclusion criteria, which incorporate other variables such as family socioeconomic status, family nucleus structure, parent psychopathology, among others. In addition, not only to increase the number of participants in each group but to add new variables of analysis that, in this study, were not contemplated, since it was tried not to alter the indications of the SENA Infantil Family scale from 3 to 6 years, in order to not provide evidence or influence the perception of parents before the reagents of the scale. In addition, a first approach to the phenomenon more conservative in its scope was required.

Finally, any approach to the psychological phenomena that arose during the quarantine period is an advance in scientific knowledge from our context, El Salvador, and therefore, it should motivate not only the replication of this knowledge but also its perfectibility, one of the most virtuous characteristics of the factual sciences.

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Comparison of normal vs. abnormal studies for automatic detection of anomalies using MRI and machine learning techniques[1]

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SUMMARY

The use of magnetic resonance imaging (MRI) includes diagnostic tasks such as monitoring many pathologies. Brain MRI captures bone, fat, cerebrospinal fluid (CSF), white and gray matter, and distinguishes its uptake in three anatomical planes: Coronal, sagittal and axial with different markings on the enhanced images: T1, T2 and FLAIR. The variation in the parameters gives different information to the radiologist, which allows to make multiple assessments on the diagnosis of a patient as well as the techniques of machine learning. Computer-aided diagnosis (CAD) includes a wide variety of tools that facilitate the decision-making process of physicians. This is based on an algorithm trained with the characteristics or patterns of a data set. In this sense, the description of the input data determines the scope of the diagnosis and the quality of response. The purpose of this study was to develop a CAD that evaluates the classification of normal subjects against patients with abnormalities, i.e. tumor, hydrocephalus, microangiopathy, among others. For this, a database composed of magnetic resonance imaging sequences enhanced in T2-FLAIR (Fluid Attenuated Inversion Recovery), of healthy and pathological controls was used. MRIs were used to train a supervised machine learning algorithm, called a support vector machine (SVM). SVM uses labeled data to learn a pattern of behavior that can predict pathological patients and normal controls. Also, results were compared with an unsupervised learning algorithm called k-means. The accuracy of the monitored model was greater than 96 %, demonstrating that SVM is a good classification technique for computer-aided diagnosis.

Keywords: magnetic resonance imaging, FLAIR MRI technique, computer diagnostics, El Salvador.

Introduction

1. Context

In Medicine, the imaging area covers acquisition and processing techniques for the study of various diseases and represents a support tool in diagnostic decision making by the medical team. More and more studies are being conducted that show that the combination of computer vision, machine learning and deep learning (Khosla *et al.*, 2019; Zaharchuk *et al.*, 2018), and medical imaging have a strong potential in the detection, prediction and differentiation of patterns in multiple pathologies. This is because the use of computational resources allows to detect patterns of behavior, even those that may go unnoticed by the expert. These patterns can be classified from one or multiple classes, allowing to separate and identify a set of samples in different groups.

In a supervised environment where machine learning techniques are used, each image has a label that identifies it, whether or not it corresponds to an anomaly. Then, ideally having a balanced data set, that is, a similar proportion for each labeled group, they are separated between training, validation and testing data for the development of future classification models. With an appropriate database, which prevents predisposition toward majority classes, this tool could generalize the main characteristics of a given cluster and extrapolate them to new data.

The FLAIR MRI technique, developed in the early 1990s (De Coene *et al.*, 1992), is a T2-weighted technique that removes the signal caused by ventricular cerebrospinal fluid, making it highly sensitive to a wide range of cortical, periventricular, and meninges diseases (Hajnal *et al.*, 1992). This technique was replacing the previous ones and it became widely used in the field of Neurology.

There is a data set of 174 magnetic resonances per image enhanced in FLAIR and their respective reading. Combining mathematical and medical sciences, these resonances will be used to create a machine learning model for the classification of normal and abnormal studies. The labeled dataset will be obtained from the diagnosis given by the medical team of the Brito Mejía Peña (BMP) clinic, which will serve to measure the performance of the supervised model. It is expected that this study will become the basis for the creation of an automatic detection system of anomalies in neuroimaging

through supervised learning models. This will streamline the workflow of the radiology clinic, creating a more autonomous image reading process.

1.1. Computer-aided diagnostics (CAD)

Over the last few years, research has contributed to the deepening of areas such as medicine and computer science. The collaborative work between both areas has allowed to deepen the understanding of diseases, increase diagnostic accuracy, study new treatments, among many others.

Although the history of artificial intelligence began in mid-1950, its application in medicine began to gain momentum at the end of the twentieth century and the beginning of the twenty-first century, especially thanks to the introduction of machine learning techniques (Kaul *et al.*, 2020), ML (for its acronym in english). Specifically in the field of medical imaging, the use of ML for the detection of behavioral patterns began in the late 1990s (Suzuki, 2017; Yan *et al.*, 2013; Doi, 2007; Doi, 2004).

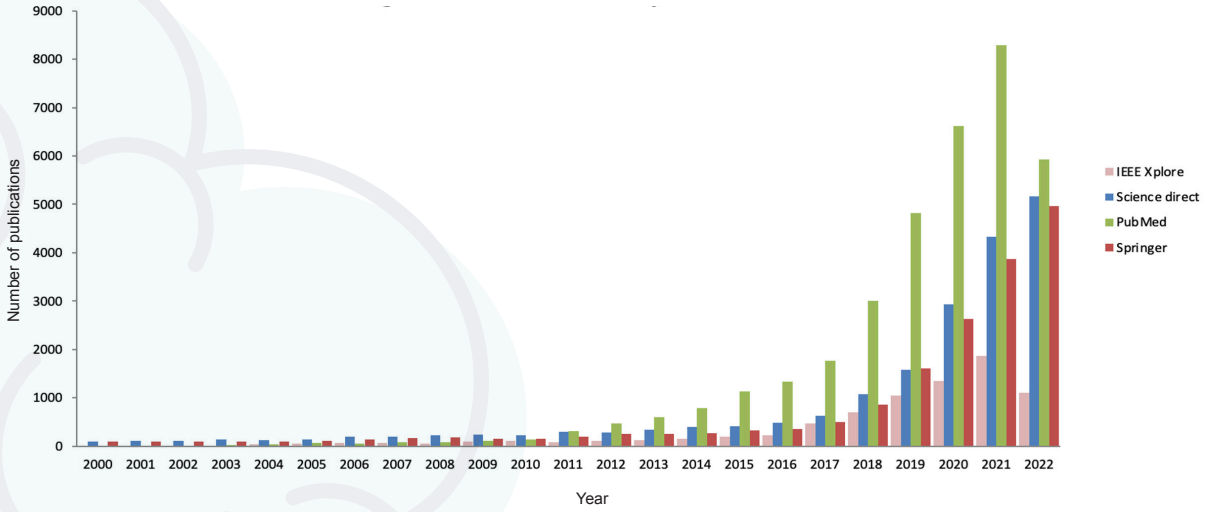
The various CAD have focused on the detection of a wide variety of pathologies; for example, the detection of colonic polyps (Yoshida *et al.*, 2001), the detection of tumors by endoscopic video (Mori *et al.*, 2017; Karkanis *et al.*, 2003), breast cancer (Astley *et al.*, 2004), pigmented skin lesions (Schmid-Saugeona *et al.*, 2003), lung diseases (Li *et al.*, 2005), among others.

Figure 1 shows the results for the boolean search of 'machine learning' and 'artificial intelligence' and 'diagnosis', in four important scientific journals: IEEE Xplore, Science direct, PubMed and Springer. The figure shows that, although the history of publications already accumulated several studies for the first decade of s. XXI, it is from the second that the increase becomes exponential.

However, this marked increase is not due to "sudden" scientific interest. Although there was already a broad theoretical basis, if these techniques had not been developed and implemented before, it is because the computational capacity of the time did not allow it. Although ML algorithms seek to facilitate diagnostic tasks, as well as many other functions, building and executing them requires a high computational cost in terms of the resources needed to operate them.

Figure 1

Number of publications in IEEE Xplore, Science direct, PubMed, and Springer using the boolean search for the terms 'machine learning' and 'artificial intelligence' and 'diagnosis'.



Source: own elaboration.

Table 1 shows some references about behavioral pattern detection through computer-assisted techniques (CAD) from the last decade. The table compares data sets, machine learning techniques, and their best results.

It also demonstrates that, in many cases, a high execution in the performance indexes can be obtained by combining these techniques with algorithms of extraction of characteristics and reduction of dimensionality and, also, that the field of study is as large as the creativity in its application.

Table 1

References about behavioral pattern detection through computer-assisted techniques (CAD) that compares data sets, machine learning and deep learning techniques and the best results obtained between 2011 and 2022.

Ref.	Year	Description BD	Technique ML	Better results	Comments and achievements
Bengs *et al.*	2022	1,735 T1-weighted 3D MRIs	Unsupervised anomaly detection (UAD) considering age	AUC=92.60 %	This study only relies on the visual appearance of healthy brain anatomy for anomaly detection, considering the deviation between brain age and chronological age, an unexplored field in combination with UAD.

Ref.	Year	Description BD	Tecnique ML	Better results	Comments and achievements
Lei *et al.*	2022	40 magnetic resonance angiography (MRA)	U-Net 3D deep learning model	Accuracy=97.19 %, sensitivity=95.87 %, specificity=100 %	Automatic localization and segmentation of aneurysms was developed using a 3D convolutional neural network (CNN) to remove potential blood vessels from the aneurysm.
Kim *et al.*	2021	265 3D MRIs: FLAIR, T1-weighted y T2-weighted	Deep neural networks for anomaly detection in iMRI	AUC value for BraTS =0.934 and AUC value for ISLES =0.87	A deep neural network is developed that uses only normal MRI images as training data. Although the proposed method demonstrated the possibility of detecting anomalies in data sets, the quantitative yield is still lower than that of the techniques supposed.
Duan *et al.*	2020	35,500 images obtained from 2,500 CT	DenseNet	Accuracy=94.0 %, sensitivity=93.6 %, specificity=94.4 %, AUC=0.93	This study demonstrates that the AI diagnostic model can diagnose hydrocephalus by reading CT images of the brain. These allow analyzing the shape and volume of the ventricle, the Evan index and age, which is a new method for diagnosing hydrocephalus.
Elshennawy *et al.*	2020	5,856 chest X-rays	RestNet152V2 pre-trained model	Accuracy=99.22 %, precision=99.43 %, AUC=99.77 %	The study compared two previously trained models, ResNet152V2 and Mobi- leNetV2, a convolutional neural network (CNN) and a short-term memory (LSTM), to detect pneumonia from chest X-ray images.
Suganthe *et al.*	2020	1,000 MRIs T1-wieghted	Model VCNN	Accuracy=96.19 %	The study compares VGG-16-inspired CNG-16 (VCNN) and deep convolutional neural network (VCNN) models to classify the different stages of Alzheimer's disease from MRIs.
Toğaçar *et al.*	2020	253 MRIs	Model BrainMRNet	Accuracy=96.05%, sensitivity=96.0%, specificity=96.08%	This architecture is built on attention models and hypercognitive technique, which allows features extracted from each layer of the BrainMRNet model to be preserved in the matrix structure of the last layer. The BrainMRNet model of this study was more successful than the pre-trained convolutional neural network models: AlexNet, GoogleNet, VGG-16.
Öman *et al.*	2019	60 CT angiography computerized (CTA)	3D CNN	Sensitivity=0.93, specificity=0.82 y ROC= 0.93	Detection of strokes improved when hemispheric brain comparison and non contrast computed tomography (NCCT) were included in the CNN analysis.
Arunkumar *et al.*	2018	110 MRIs	K-means with ANN technique	Accuracy=94.07 %, sensitivity=90.09 %, specificity=96.78 %	The study developed the K-media agrouping technique to select the best region, and assessed the competency of the results by comparing the results of ANN, SVM, and tumor case classification.
Vargas *et al.*	2018	396 CT perfusion images	Long-Term Recurrent Convolutional Network (LSTM)	Accuracy=85.8 %	Network predictions were compared with interpretations of CT perfusion maps from trained neuroradiologists. This suggests that such modes could assist in the opportune detection of perfusion deficits.
Rebouças *et al.*	2017	420 CT images of the skull	Brain tissue density analysis (ABTD)	Accuracy=99.30 %	ABTD with classifiers such as MLP, SVM, kNN, OPF and Bayesian was applied to classify whether a CT image represented a healthy brain or one with an ischemic or hemorrhagic stroke. Optimum Path Forest (OPF) had the shortest extraction time and highest average accuracy when combined with Euclidean distance. In addition, the average accuracy values for all classifiers were greater than 95%.

Ref.	Year	Description BD	Tecnique ML	Better results	Comments and achievements
Firmino *et al.*	2016	420 CT images	Rule-based classifier and support vector machine (SVM)	Accuracy of 97 % and sensitivity of 94.4 % with 7.04 false positives per case	This work developed a new CADx system of pulmonary nodules in CT images, grouping them into a single nodule identification and characterization system to improve the level of automation. It also diagnoses malignancy, with AUC=0.91 for nodules with little probability of malignancy, 0.80 moderately unlikely, 0.72 indeterminate, 0.67 moderately dull and 0.83 very suspicious.
Rouhi *et al.*	2015	163 mammograms	Multilayer perceptron (MLP)	Accuracy=96.47 %, sensitivity=96.87 %, specificity=95.94 %	The artificial neural network formed by multiple layers, MLP, is trained using a reverse propagation (BP) algorithm. The goal of this algorithm is to minimize the error between the network output and the target vectors.
Hirschauer *et al.*	2015	604 [123I]FP-CIT SPECT	Enhanced Probabilistic Neural Network (EPNN)	Accuracy=0.986	Patients with Parkinson's disease were also classified against scans without evidence of dopaminergic deficiency (SWEDD) and obtained a classification accuracy of 92.5% using EPNN. Other classifiers used were: probabilistic neuronal network (PNN), SVM, k-NN and decision tree (DT).
Matulewicz *et al.*	2014	18 MRI/MRSI	ANN	AUC = 0.968	Two ANN models were implemented and compared for the automatic classification of prostate MRSi: model 1, which uses spectra as input, and model 2, which uses spectra together with anatomical segmentation information. Model 2 (AUC = 0.968) provided a significantly better rating than model 1 (AUC = 0.949).
Montejo *et al.*	2013	219 diffuse optical tomography (DOT) images	SVM	Sensitivity=100.0 %, specificity=97.8 %	The study compared 5 classification algorithms: linear discriminant analysis (LDA), quadratic discriminant analysis (QDA), k-nearest neighbors (KNN), self organizing maps (SOM) and support vector machines (SVM).
Mohsen *et al.*	2012	101 MRIs (14 normal and 87 abnormal – benign and malignant tumors)	Backpropagation Neural Network (BPNN)	Accuracy=99%	A neural network coupled to applied feedback pul- sos (FPC-NN) was used for image segmentation and detection of the region of interest (ROI), followed by a discrete wavelet trans- form (DWT) to extract features; in addition, a principal component analysis (PCA) was performed to reduce the dimensionality of the wavelet coefficients, resulting in a more efficient and accurate classifier. The reduced functions were sent to the BPNN to classify the entries into normal or abnormal.
Tang *et al.*	2011	101 DICOM CT	Stroke CAD	Sensitivity=93.33%, specificity=90.3%	This CAD included several algorithms for detection of ischemic stroke, including: location of the symmetrical axis of the brain, extraction of skull bone with preservation of cranial contents, circular adaptive ROI to detect areas of subtle density change, tracking of the anatomical midline of the brain by computer method.

Source: own elaboration.

1.2. Terminology

AI	*Artificial intelligence*
ML	*Machine learning*
SL	*Supervised learning*
UL	*Unsupervised learning*
CV	*Computer vision*
MRI	*Magnetic resonance imaging*
CAD	*Computer-aided diagnosis*
FLAIR	*Fluid attenuated inversion recovery*

2. Objetives

2.1. General objective

This study proposes techniques of unsupervised machine learning and supervised learning. It is, on one hand, the k-means algorithm; on the other hand, a support vector machine (SVM) for supervised learning of brain MRI traits and classification of normal and pathological subjects.

2.2. Specific objectives

- Make an assessment of the quality of the data provided by the clinic.
- Develop a k-means model that groups the database into normal and abnormal subjects without prior knowledge of labels.
- Model an SVM algorithm that generalizes the characteristic features of both groups and determines the probability of belonging to each.
- Establish and implement indicators that allow a statistical analysis of the supervised learning model.

3. Metodology

3.1. Database

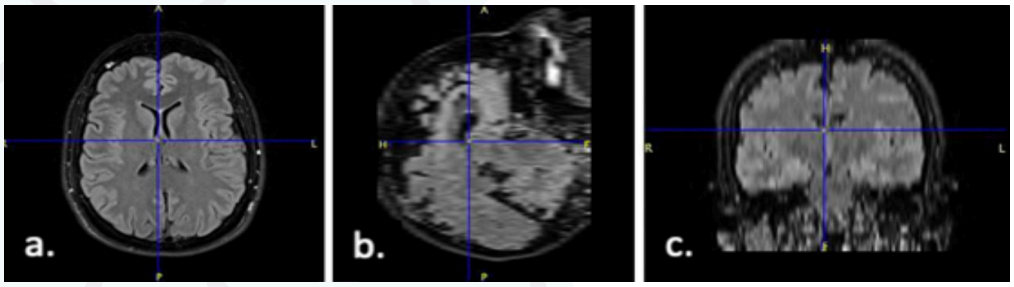
To make a model generalizable, it must have been trained with a database large enough to say that the algorithm has "learned the task"; almost in the same way that a specialist has achieved sufficient experience in his area, having seen a varied number of patients.

In this sense, between the corresponding period of May 1 to September 20, 2022, a database of MRI T2-FLAIR of the resting brain was collected. This database was used for training and validation of a classification algorithm. A Siemens Avanto 1.5 Tesla equipment was used for a brain evaluation with rapid gradient echo sequences (MPRAGE) T1 with and without contrast E.V, i.e. gadolinium, T2, FLAIR, diffusion imaging (DWI) and magnetic susceptibility imaging (SWI) in the different orthogonal planes.

For the purposes of this project we will use T2-FLAIR enhanced imaging, or fluid attenuated investment recovery (Figure 2). Albin *et al.* (2022) points out that FLAIR sequences are performed in anatomical uptake, detection of chronic pathologies, edema and demyelination. This case justifies his study for multiple sclerosis (Rovira *et al.*, 2010), different types of tumors (Zeineldin *et al.*, 2020), hydrocephalus (Sener, 2002), in microangiopathies (Wardlaw *et al.*, 2013), among others.

Figura 2

Example of axial (a), sagittal (b) and coronal (c) weighted acquisition slice in T2-FLAIR.



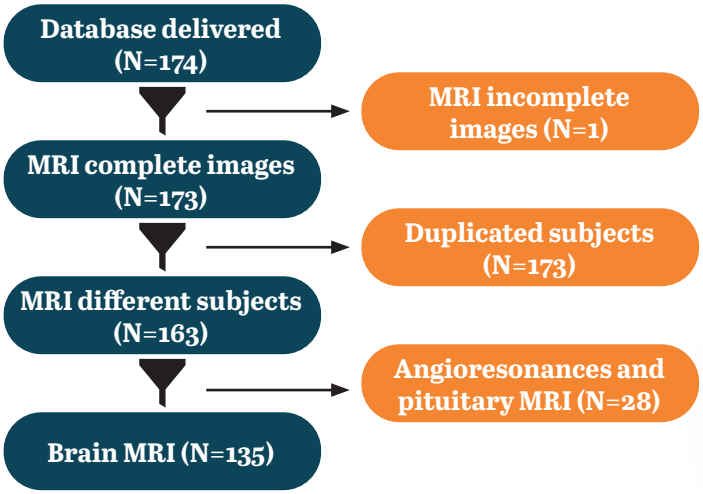
Source: own elaboration.

According to the clinical data, prepared by the medical team, the referred patients manifest the following pathologies: hydrocephalus, microangiopathy, tumor, infarcts, cysts and cerebral atrophy in different degrees. The database also includes control studies, i.e. normal.

The FLAIR MRI is the first image studied by the medical team prior to further evaluation using the different weighted MRs. What is intended to define in the present work is whether FLAIR MRI could be a good classifier to perform a successful prediagnosis. Therefore, prior to the analysis process, a first purification of the data was carried out, as shown on the flow diagram in the follow Figure 3, where the exclusion criteria is also specified.

Figure 3

Flowchart showing the cleaning process for this study.



Source: own elaboration.

Out of a total of 174 subjects delivered by the clinic, subjects with incomplete MRI scan (n=1) were excluded, where only a two-dimensional image was found, subjects who were duplicated (n=10), and subjects with MRI with different sequences were excluded, as are angioresonances and MRI of the pituitary (n=28).

After data cleansing, the final database was reduced to a total of 135 T2-FLAIR-enhanced MRI studies. Patient demographic information is detailed in Table 2.

Table 2

Demographic data of the group collected for this work, grouped by age and sex.

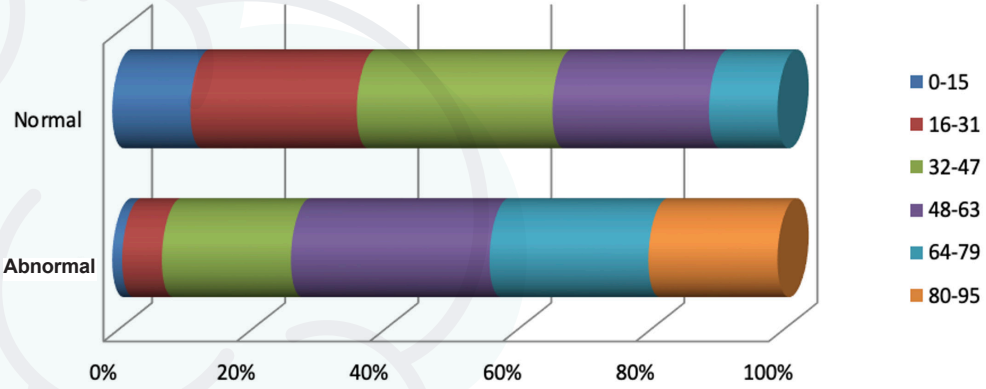
Age range	Woman	Man	Total
0-15	6	3	9
16-31	15	6	21
32-47	21	12	33
48-63	22	14	36
64-79	13	10	23
80-95	10	3	13
Total	**87**	**48**	**135**

Note: this is the total number of patients that will be used for training, validating and testing the classification algorithms.
Source: own elaboration.

Later, a supervised learning technique will be applied, so the clinical data of each subject was collected, a label provided by the medical team, who classified the studies as normal or abnormal. Figure 4 shows the proportion of demographic data used for supervised learning classification algorithm training.

Figure 4

Proportion of demographics labeled 'Normal' and 'Abnormal'.



Source: own elaboration.

3.2. Standardization

One of the aspects to consider when treating medical images is that, prior to the classification process, it is necessary to pre-process MRIs that are in their raw state, i.e. 'raw data'.

Each resonance can contain different types of artifacts in the image, i.e. differences in intensity, size, or false structures (Sartori *et al.*, 2015). In the same way that a radiologist might misinterpret an MRI due to MRI distortion, a classification algorithm could also misdiagnose if these deficiencies are not overcome. We call this pre-processing normalization, and it consists of harmonizing the data before analyzing it. Then, we will explain its importance within this research.

Unlike a computer, a radiology doctor knows that an MRI can contain:

- Regions of the subject that do not belong to the area of interest, in this case, the brain, and that could even appear as an incomplete projection on the resonance.

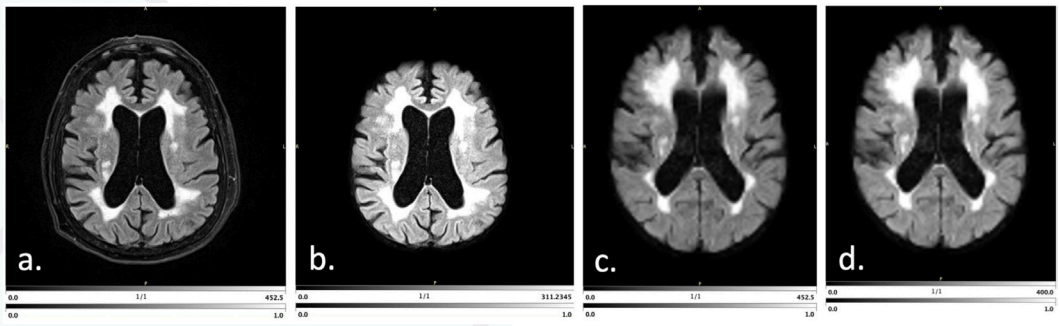
- Images that are misaligned or distorted due to a change in the magnetic field in some areas of the brain.
- Because of the time it takes to complete the study, subjects often move within the scanner, voluntarily or involuntarily, which can cause:
  - » False correlations between different regions of the brain.
  - » That the image is not aligned with itself.
  - » Ghost images or replicas of a moving structure that can often be observed in the outline of the image.
  - » Blurring or decrease in image resolution.
- For the same reason, the subjects participating in the study will hardly be aligned with each other, making it difficult to extract behavioral patterns.

Taking into account the above, the following process was followed for the normalization of the images:

a. Reading the database already purged from incomplete, duplicate and different run studies.
b. Extraction of the brain. For the preprocessing of the FLAIR images we have, it is necessary to extract the organ of interest from the bone system that protects it. This is because, in some cases, the study that includes the skull shows variations that could confuse the algorithm with other abnormalities, i.e. variations in a post-surgical skull.
c. Normalization. MRIs were normalized with a reconstructed hemifacial spasm (HFS) MRI template. This template contains the morphological information of the head, so when merged with each image, the result is an MRI study correlated with the patient's morphology. Thus, by segmenting the study each region of the brain is easily recognizable. This process allows parameterizing all studies in the same normalized space, and enables cross-sectional analysis.
d. Homogenization of the threshold of the color map, so that the intensity of the image oscillates in the same values.

Figure 5

'Raw data' preprocessing sequence where: (a) A patient reading with 34 x 320 x 320 resolution is observed, (b) Brain extraction, (c) Template normalization with 91 x 109 x 91 resolution, and (d) Intensity threshold correction.



Source: own elaboration.

3.3. Unsupervised learning with k-means

Unsupervised learning tools allow you to make a distribution of the data when it is not labeled. The k-means technique, for example, allows you to group a set of data into clusters that share specific behavior patterns. K-means, where k represents the number of clusters, iteratively assigns points to the nearest cluster, and calculates its centroid until it converges. This technique has applications in multiple fields, including: market segmentation, computer vision, text analysis or text mining, identification of crime prone areas, optimization of delivery times, prediction of traffic zones in the city, analysis of calls, detection of fraud in banks and insurance agencies, detection of cybercrime and a long etcetera. We will use this unsupervised learning algorithm as the first approximation for the classification of our magnetic resonance database.

K-means uses a default number of clusters to measure the vector distances of the reference pattern set by each voxel. Starting at an arbitrary point, the algorithm assigns a centroid to a dataset and, at each iteration, averages the sum of the data to generate a new centroid. This process runs until the cluster size is unchanged, that is, until it converges (Equation 1).

Equation 1

Squared error function. Given a number of clusters k, the k-means algorithm seeks to minimize the total variance within the cluster, which is calculated using this equation.

$$E = \sum_{j=1}^{k} \sum_{i=1}^{n} \left\| x_i - c_j \right\|^2$$

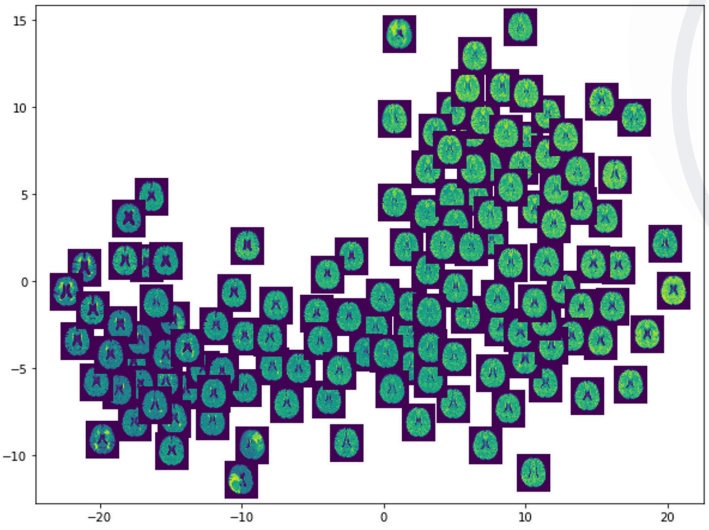
Where in:

$\left\| x_i - c_j \right\|^2$ is the distant function
k is the number of clusters
n is the number of data
x_i is the value *i*
c_j is the center of cluster *j*

Applying this method to our database, we have a set of brain magnetic resonances, which we can visualize with the help of Figure 6. For the implementation of the unsupervised learning technique, we use Python programming language and scikit-learn functions scikit-learn (https://scikit-learn.org) for K-means modeling.

Figure 6

Visualization of the database placed within the same coordinate system.



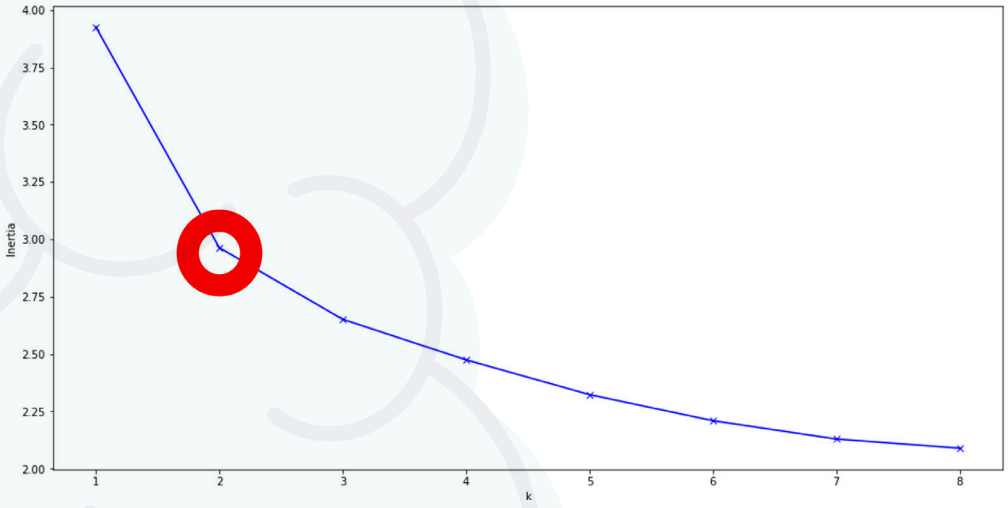
Source: own elaboration.

Although k-means is a low computational cost algorithm, which makes it very quick to run, it can be difficult to determine the optimal number of clusters in which to separate the data and group images that do not necessarily belong to the same group.

To solve this problem, we will apply the elbow method that uses the function of Equation 1 to calculate the sum of the squared distances of the samples to their nearest center, i.e. centroid. The elbow method was applied to the MRI database (see Figure 7).

Figure 7

Elbow method for selecting the optimal number of clusters using the MRI database. Display a range between 1 and 8 clusters.



Source: own elaboration.

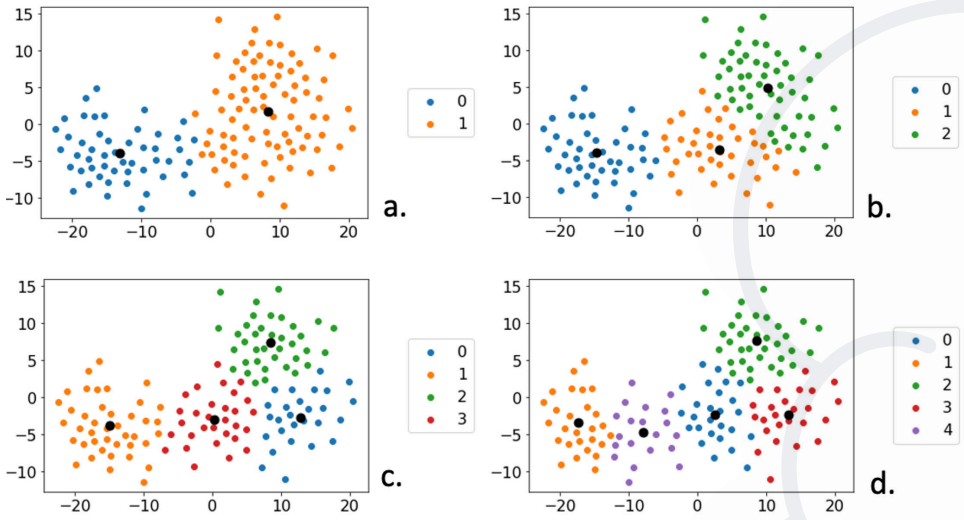
As can be seen in Figure 7, as k increases, this value tends to zero, which makes it easier to detect the distribution that allows a greater concentration or closeness between its points. That is why the optimal k that is chosen corresponds to the number of clusters where the slope of the curve makes a more pronounced change compared to the clusters that follow it. In our case, you can observe the change of inclination from k=2, consecuently we will analyze the results for that number of clusters.

The results of the grouping in k=2 clusters can be seen in Figure 8a. (see annex: Table 6 for binary classification). To compare, we also add the visualization of the classification that the algorithm would do in case of dividing the database in k=3 (Figure 8b.), k=4 (Figure 8c.) And k=5 (Figure 8d.) clusters. One of the many advantages of k-means

include its low computational cost, and the ability to detect patterns on its own, even those that might have been overlooked. The fact that k-means is based solely on the data entered, omits the bias that could imply a medical diagnostic error.

Figure 8

Grouping results using k-means unsupervised learning technique for k=2 (a), k=3 (b), k=4 (c) and k=5 (d).



Source: own elaboration.

On the other hand, in the medical field, studies are not always limited to a positive or negative diagnosis. The same pathology could have several intermediate states, e.g. atrophy states, angiopathies, tumors, etc. However, this first approach gives us a perspective on the distribution of our data, and brings us closer to our goal of creating a CAD that streamlines the diagnostic process of a radiological clinic.

3.4. Supervised learning with Support Vector Machines (SVM)

Unlike the technique discussed in the previous section, supervised learning algorithms need labeled data to be trained. As stated at the end of section 3.1 Database, to label all studies we collected the clinical data of each subject, and combined that information with a label provided by a specialist physician, who classified each study as normal or pathological. The criteria for generating the label for ML algorithm training was as follows:

- If both sources agree to assign a normal or abnormal study label, that will correspond to the label for algorithm training.
- If the clinical data also mentions a pathological history reflected in the MRI, the label of said study will be 'abnormal'.
- If the clinical data labels a study as 'normal' considering age factors, but the doctor labeled it as 'abnormal', the study will be taken as 'abnormal'[2].

Figure 4 shows the proportion of demographic data used for supervised learning classification algorithm training. The variety of methods applied for the development of computer-aided diagnostics (CAD) has already been mentioned. The methodology that this 'Support Vector Machine' model will follow is divided into four stages, specified in Table 3.

Table 3

The four stages of the support vector machine algorithm for the detection of anomalies in F2-FLAIR magnetic resonances.

Stage 1. Reading and normalization
1. Given a raw database. 2. Filter database according to exclusion criteria. 3. Import and read the data in pixel_array using 'pydicom' package in Python. 4. Normalize pixel values. 5. Divide the labeled dataset into training/testing set (80% / 20%)
Stage 2. Modeling
6. We use GridSearchCV to optimize estimate parameters, including C, kernel, and gamma 7. Combination of best parameters: {´C´:5,´gamma´:´scale´,´kernel :´rbf´,´random_state´:0}. 8. Apply cross-validation k-fold to avoid overfitting the model with k=10 9. Generate SVM model using parameters and cross-validation technique with training data
Stage 3. Model evaluation
10. Evaluate the model according to performance metrics: accuracy, precision, recovery, F-value and AUC. 11. Select model. 12. Run the classification model with the test data.
Stage 4. Classification
13. Classify the studies according to the degree of belonging to each group.

Source: own elaboration.

2 This will be discussed later, in the section of Future lines of work.

Having the model trained with the portion of the data destined for the binary classification task, we evaluated the accuracy with which the SVM model is able to predict the binary diagnosis, with a result of 96.3 %. The precision, recovery and F-value indicators, calculated according to the formulas in Equation 2, are listed in Table 4.

Equation 2

Given True Positive (PV), True Negative (VN), False Positive (FP) and False Negative (FN), (a) Calculates the portion of studies on the sample that were correctly classified, both normal and abnormal, (b) Balculates the portion of studies classified as normal, (c) Calculates the portion of normal studies that were correctly classified and (d) Measures the relationship between accuracy and recovery obtained.

$$\frac{VP+VN}{VP+VN+FP+FN} \quad \text{(Accuracy)} \quad \text{(a)}$$

$$\frac{VP}{VP+FP} \quad \text{(Precision)} \quad \text{(b)}$$

$$\frac{VP}{VP+FN} \quad \text{(Recuperation)} \quad \text{(c)}$$

$$2 * \frac{\text{precision} * \text{recuperation}}{\text{precision} + \text{recuperation}} \quad \text{(Value)} \quad \text{(d)}$$

Table 4

Accuracy, recall, and F-value (F1- score) performance indicators of the SVM model for the classification of T2-FLAIR MRIs, where (0) represents abnormal studies and (1) normal studies.

	Precision	Recovery	Value-F
Abnormal (0)	0.98	0.95	0.96
Normal (1)	0.94	0.98	0.98

Source: own elaboration.

Given a balanced database like ours (with 68 normal and 67 abnormal studies), the operating characteristic curve of the ROC receptor (for its acronym in English),

provides a graphical representation of the performance of our binary classifier. As mentioned in Equation 2, the model, once trained, generates correct predictions of normal studies (1), true positive, or may be mistaken in the prediction, false positive (see Table 5).

Table 5

Confusion matrix for the calculation of performance indicators.

		PREDICTION 0	PREDICTION 1
MEDICAL LABEL	0	VN	FP
	1	FN	VP

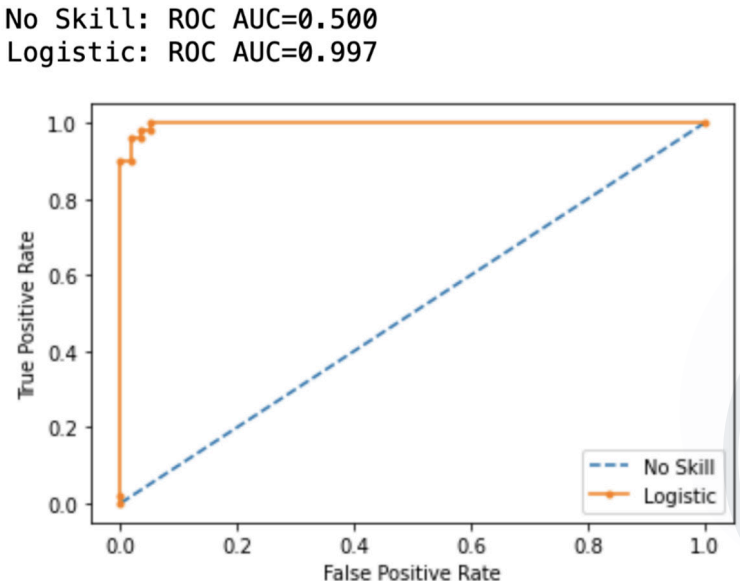
Source: own elaboration.

The ROC curve facilitates the visualization of the predictive power of a model, and allows its comparison with other binary classification models. Thus, a predictive model with an accuracy of 100 % would look like an inverted L; while a completely random prediction model would look like a vertical line crossing the figure from the lower left corner to the upper right corner (Figure 9, the blue dotted line).

Having the ROC curve, we can quantify its performance by calculating the area under the curve (AUC). As explained above, being the space where the curve is plotted a square, it can be predicted that the AUC of a model with a perfect classification will be 1, while that of a random classification model will be 0.5. Therefore, as long as the AUC value is closer to 1, the performance of the model will be better; while, if it approaches 0.5, the result of the prediction will be similar to that obtained by throwing a dice: random.

Figure 9

ROC and AUC curve for the SVM supervised learning model.



Source: own elaboration.

Figure 9 shows the ROC curve and the value of the area under the curve (AUC = 0.997) for the model we have trained with our T2-FLAIR MRI database. It is important to mention that, although an AUC = 1 is tempting, in some cases it reflects an over-adjusted model. A perfect classification model could be a classifier that "has learned the task too well" for a given set of data, without generalizing the pattern of the same for classification. This behavior of "memorizing" the data prevents you from extrapolating the task to new data.

The accuracy, precision, recovery, F-value, and area under curve (AUC) results demonstrate that our proposed supervised learning framework performs excellently. However, it would be a mistake to finish this article without first adding the limitations that were found throughout this research.

4. Limitations

The first and most obvious limitation is the acquisition of medical images. Supervised machine learning algorithms must be fed with huge databases labeled to be well trained. In this research a total of 174 images were received, of which 39

were discarded because they were incomplete, repeated or acquired in a different sequence, which left us a total of 135 MRIs. Meanwhile, for an accurate classification of normal and abnormal images, it is important to have a considerable amount of images that allow learning the specific characteristics of both groups. In addition, it should be mentioned that, within the resonances labeled as abnormal, the clinical data indicates that many have two or more pathological conditions, which increases the variability within the same group and hinders the learning of the characteristics, especially when the database is small.

For the task of labeling the data and being able to train the supervised algorithm, the medical team was asked to add the label. Although most of these were classified, approximately 20 % were labeled according to the reading of the order for the preclassification of the data. Although the reading summarizes everything that is observed in the resonance, this step introduces an exception in the criterion, which reduces consistency in the process and reliability in the result. It should be mentioned that this labeling process was used as a "true standard" for classifier training. That is, the results obtained by the algorithm will always depend on the validity of the data labeled with which it was trained. For this reason, it could be indicated that the algorithm is correct or not in its prediction, to the extent that the medical team has been successful in the diagnosis.

5. Conclusions

In this study, 135 T2-FLAIR-enhanced brain MRIs were used to apply machine learning techniques as a computer-aided diagnostic method. Based on the usual assessment by a clinic's medical team, this information was used to classify resonances as 'normal' or 'abnormal'. Of the database, 80 % was allocated to train the model and 20 % to test it. The accuracy result for the SVM supervised learning model was 96.3 % in agreement with the classification made with the help of the medical team.

Since in the medical field it is difficult to make a global separation between positive and negative diagnoses, the fact that the prediction of the learning algorithm supervised provide a 'degree of belonging' to one or another group makes the results obtained more flexible (see annex: Table 7). From this perspective, unlike k-means, whose classification is rather hard, SVM gives the percentage of probability that an MRI study is normal or pathological.

6. Future lines of work

In one of the criteria for labeling the images, it was explained that, if the clinical data labels a study as 'normal' considering age factors, but the doctor labels it as 'abnormal', the study will be taken as 'abnormal'. If you have a database large enough for different age ranges, computer vision techniques could be used to make a classification of MRI anomalies that takes into account the demographic characteristics of the database. This will allow to create a more 'fine' classifier, e.g. an abnormal study for a subject in the range of 15 to 60 years, could be classified as normal for a subject exceeding that range.

With the same logic, having a balanced database with different pathologies would help to create a multiclass supervised learning algorithm. Rather, if we feed the database that we have with more patients with hydrocephalus, tumors, microangiopathies, etc., we could classify not only groups of normal and abnormal subjects, but, among the abnormal ones, predict the percentage of belonging to a certain pathology.

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Annexes

Table 6

Grouping results using k-means unsupervised learning technique with magnetic resonance database, with k = 2. The label corresponds to 1 for 'normal' and 0 for 'abnormal'.

ID	K-means (k=2)
1	1
2	1
3	1
4	1
5	1
6	1
7	1
10	1
11	1
12	1
13	1
14	1
15	1
16	1
18	1
19	1
20	1
22	1
24	1
25	1
26	1
27	1
28	1
31	1
36	1
37	1
38	1
39	1
40	1
41	0
42	1
43	1
44	1
45	1
46	1
47	1
48	1
49	1
50	1
51	1
52	0
53	0
54	1
55	0
56	1

ID	K-means (k=2)
57	0
59	1
60	0
61	1
62	0
63	1
64	0
65	1
66	0
67	1
68	1
70	1
71	1
72	1
73	0
74	0
76	0
79	1
80	0
82	1
83	1
84	1
85	1
86	0
87	1
88	1
89	1
90	1
91	1
92	1
104	1
105	1
106	0
107	1
108	0
109	1
110	1
111	0
112	1
113	1
115	0
116	0
118	0
119	1
120	0

ID	K-means (k=2)
121	1
122	0
123	0
126	1
127	1
128	1
129	1
130	1
131	1
132	1
133	1
134	1
135	0
137	0
138	0
139	1
140	1
141	1
142	1
143	1
144	1
145	1
146	0
148	1
149	0
150	1
151	0
152	1
153	1
155	1
158	0
159	1
160	1
161	0
162	1
163	0
164	0
166	1
167	0
168	1
169	1
170	0
171	1
172	1
174	1

Source: own elaboration.

Table 7

Results of the grouping of test data using supervised learning technique of SVM with magnetic resonance database. The label corresponds to 1 for 'normal' and 0 for 'abnormal'. Studies with red letters correspond to those whose predictive label does not correspond to the clinic label.

ID	Normal (1)	Anormal (0)
['001''1']	83.97%	16.03%
['002''1']	83.98%	16.02%
['003''1']	83.98%	16.02%
['004''1']	83.97%	16.03%
['005''1']	83.98%	16.02%
['006''1']	83.98%	16.02%
['007''1']	83.97%	16.03%
['010''1']	85.59%	14.41%
['011''1']	83.97%	16.03%
['012''1']	83.98%	16.02%
['013''1']	83.98%	16.02%
['014''1']	83.97%	16.03%
['015''1']	83.98%	16.02%
['016''1']	83.97%	16.03%
['018''1']	83.98%	16.02%
['019''1']	83.97%	16.03%
['020''1']	83.98%	16.02%
['022''1']	91.37%	8.63%
['024''1']	83.97%	16.03%
['025''1']	83.97%	16.03%
['026''1']	83.98%	16.02%
['027''0']	18.10%	81.90%
['028''1']	67.56%	32.44%
['031''0']	82.57%	17.43%
['036''1']	83.97%	16.03%
['037''0']	24.44%	75.56%
['038''1']	83.97%	16.03%
['039''1']	83.97%	16.03%
['040''0']	27.18%	72.82%
['041''0']	12.20%	87.80%
['042''1']	83.97%	16.03%
['043''1']	83.97%	16.03%
['044''1']	83.97%	16.03%
['045''1']	83.97%	16.03%
['046''1']	83.99%	16.01%
['047''1']	83.98%	16.02%
['048''1']	83.98%	16.02%
['049''1']	83.97%	16.03%
['050''1']	83.98%	16.02%
['051''0']	14.71%	85.29%
['052''0']	12.20%	87.80%
['053''0']	0.76%	99.24%
['054''1']	83.97%	16.03%
['055''0']	0.36%	99.64%
['056''1']	83.97%	16.03%
['057''0']	6.80%	93.20%
['059''1']	56.85%	43.15%
['060''0']	12.20%	87.80%
['061''1']	83.97%	16.03%
['062''0']	11.63%	88.37%
['063''1']	83.98%	16.02%
['064''0']	12.20%	87.80%
['065''0']	12.20%	87.80%
['066''0']	2.87%	97.13%
['067''1']	83.98%	16.02%
['068''1']	83.98%	16.02%
['070''1']	78.85%	21.15%
['071''0']	40.25%	59.75%
['072''1']	83.97%	16.03%
['073''0']	0.93%	99.07%
['074''0']	12.20%	87.80%
['076''0']	5.91%	94.09%
['079''0']	44.80%	55.20%
['080''0']	12.20%	87.80%
['082''0']	12.21%	87.79%
['083''0']	33.22%	66.78%
['084''1']	83.97%	16.03%
['085''1']	83.98%	16.02%
['086''0']	12.21%	87.79%
['087''0']	37.74%	62.26%
['088''0']	53.37%	46.63%
['089''0']	30.89%	69.11%
['090''0']	18.53%	81.47%
['091''0']	12.21%	87.79%
['092''0']	60.56%	39.44%
['104''0']	12.20%	87.80%
['105''1']	83.98%	16.02%
['106''0']	12.20%	87.80%
['107''0']	47.32%	52.68%
['108''0']	12.20%	87.80%
['109''0']	12.20%	87.80%
['110''1']	83.98%	16.02%
['111''0']	1.41%	98.59%
['112''0']	12.20%	87.80%
['113''1']	83.98%	16.02%
['115''0']	12.20%	87.80%
['116''0']	3.98%	96.02%
['118''0']	4.45%	95.55%
['119''0']	12.20%	87.80%
['120''0']	12.21%	87.79%
['121''1']	83.98%	16.02%
['122''0']	3.64%	96.36%
['123''0']	12.20%	87.80%
['126''1']	83.97%	16.03%
['127''1']	83.97%	16.03%
['128''1']	83.97%	16.03%
['129''0']	13.46%	86.54%
['130''0']	12.21%	87.79%
['131''1']	78.05%	21.95%
['132''0']	17.73%	82.27%
['133''0']	17.98%	82.02%
['134''0']	21.95%	78.05%
['135''0']	2.29%	97.71%
['137''0']	1.60%	98.40%
['138''0']	3.08%	96.92%
['139''1']	83.98%	16.02%
['140''0']	37.96%	62.04%
['141''1']	83.97%	16.03%
['142''1']	83.97%	16.03%
['143''1']	83.97%	16.03%
['144''0']	37.03%	62.97%
['145''0']	38.84%	61.16%
['146''0']	12.21%	87.79%
['148''1']	82.26%	17.74%
['149''0']	1.25%	98.75%
['150''0']	12.20%	87.80%
['151''0']	8.01%	91.99%
['152''0']	37.89%	62.11%
['153''0']	49.22%	50.78%
['155''1']	83.97%	16.03%
['158''1']	50.00%	50.00%
['159''0']	26.90%	73.10%
['160''1']	83.98%	16.02%
['161''0']	8.49%	91.51%
['162''1']	83.98%	16.02%
['163''0']	0.49%	99.51%
['164''0']	12.20%	87.80%
['166''1']	83.97%	16.03%
['167''0']	1.59%	98.41%
['168''1']	83.97%	16.03%
['169''1']	83.98%	16.02%
['170''0']	0.99%	99.01%
['171''1']	83.98%	16.02%
['172''0']	12.20%	87.80%
['174''1']	83.99%	16.01%

Source: own elaboration.

Efficiency and safety of transcranial magnetic stimulation (TMS) in the treatment of juvenile depression[1]

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SUMMARY

The purpose of this study is to compare the effectiveness and safety of drug therapy versus TMS therapy and drugs. Twelve patients with drug-resistant depression between 14-18 years old (M=16.42) were considered. Transcranial magnetic stimulation allows non-invasive stimulation of the human brain and cranial nerves that can modify the excitability of the cerebral cortex (Alisauskiene *et al*., 2005), allowing a new field of investigation of neural circuits. For this reason, it's becoming a therapeutic tool for various psychiatric and neurological diseases. The research evaluated two groups: an experimental group consisting of outpatients on pharmacological treatment (N=6) who received 30 sessions of open-label TMS (Experimental Group), and a control group consisting of patients with depression on pharmacological treatment (N=6) who did not receive TMS. By means of the Hamilton Depression Rating Scale (HDRS), the severity and progress of the illness was followed up in all the participants, in the same periods of time: before the investigation, after 3 weeks, and a last one at the 6 weeks of treatment. The results obtained showed that TMS treatment combined with the use of drugs is safe and even more efficient than drugs alone in patients with drug-resistant depression, when the drugs are controlled and monitored by the responsible physician. In addition, the hybrid treatment was shown to relieve patients of depression symptoms in a shorter period of time.

Keywords: depression, antidepressants, neuroplasticity, selective serotonin reuptake inhibitors (SSRIs), psychotherapy, El Salvador.

Introduction

Juvenile depression is a serious public health problem due to its evident effects on the increase in adolescent pregnancy cases, substance dependence, academic and professional failure, cognitive impairment, family deterioration and suicide. According to the above, this study seeks to demonstrate the importance of providing comprehensive care when treating mental health and ensuring the well-being of the population.

Depression is a neuropsychiatric disease that is attributed to abnormalities related to neurotransmitters and monoamines (serotonin, noradrenaline and dopamine), which affect various brain circuits and structures responsible for mood regulation. Neuroimaging studies reveal that the amygdala, responsible for processing reward and threat stimuli, is overactive and responds excessively to negative events in patients with depression. This structure is connected to various regions in the brain, which regulate the physiological and behavioral response to emotional stimuli, including the medial prefrontal cortex, the nucleus accumbens, the hippocampus and the insula (Mayberg *et al.*, 1999).

This and other changes in patients with depression result in inappropriate responses to emotional events, so treatments such as antidepressants, psychological therapy, electroconvulsive therapy and transcranial magnetic stimulation, seek to affect the structure and function of the regions of the brain affected by this disease.

According to data from the Ministry of Health of the Republic of El Salvador (MINSAL), the national rate records 3,965 cases of adolescents between 15 and 19 years with depression. The alarming number of cases in adolescents is more concerned when juvenile depression is related to the development of heart problems, neurodegenerative diseases and decreased immune health, so it becomes a social and economic cost to society in the long term. In 2016, the country lost 2.48 % of its total GDP, equivalent to USD 537 million due to mental health disability (Contreras, 2018). The responsibility lies in the shortcomings faced by the country such as the lack of personnel, since between 2011 and 2015, 2.7 % of medical graduates chose Psychiatry as their specialty.

Doran and Kinchin (2020) have been dedicated to explaining the impact that mental health has on the development and economy of a country. For example, in 2014

approximately 6,912 young people in the world's most developed countries took their lives. These deaths, considered preventable, resulted in a loss of 406,730 years of life at a cost of 5,530 million in lost economic income, with an average suicide cost estimated at USD 802.939. That is why the intervention and investment of governments and NGOs in programs with a multifaceted approach, is necessary to reduce youth suicide and, in this way, protect their growth and economy.

Previously, it was mentioned that there are several interventions to treat depression, the best known, drug use and psychotherapy. However, these can often have suboptimal, counterproductive results with uncertain safety profiles, especially in a brain that is still developing as in children and adolescents, but all have the same goal: to stimulate neuroplasticity. For his part, Merzenich (2013), observed that the brain is highly plastic, allowing it to change and adapt to intrinsic and extrinsic factors through neuroplasticity, and together with this discovery, the hope of new therapeutic methods for different neurological and psychiatric pathologies arose (Albert, 2019; Rădulescu *et al.*, 2021).

On the other hand, the term 'neuroplasticity' refers to a series of processes in the central nervous system, in response to certain stimuli that allow the brain to reshape its structure and reconnect its connections, either by strengthening or weakening synaptic transmission. This process is involved in brain development, memory creation and learning, healing of the brain after stroke, but likewise, it can be perceived negatively in mental illness, when the process of synaptic reorganization is maladaptive and can lead to the persistence of psychiatric symptoms. Interruption of top-down processing is responsible for sadness and negative affect in depressed patients by decreasing activity in the prefrontal and parietal cortex, and increases anterior insula activity. This deregulation can be the cause of altered emotional responses to negative stimuli. Based on this reasoning, Mutschler *et al.* (2012) found that, in patients with depression, emotional processing is diverted to the dorsal insula, a region responsible for of pain processing in healthy people, suggesting an explanation for emotional allodynia in depressed patients.

The goals of antidepressants are to relieve depressive symptoms and enhance serotonin and noradrenaline activity in different ways depending on the group to which they belong; however, it is not fully known how they act or achieve their goal (Briley and Moret, 1993). Selective serotonin reuptake inhibitors (SSRIs), for example, appear to

be effective in relieving symptoms of depression (NHS, s.f.). However, researchers such as Geddes *et al.* (2003) show that, when administered acutely, they have little effect on synaptic levels of serotonin, proposing the existence of one or more regulatory mechanisms that control serotonergic neurotransmission.

It is recommended to prolong the use of SSRIs, as they are not only prescribed to relieve depressive symptoms in the short term, but also to prevent future depressive episodes. Geddes *et al.* (2003), found that continuation of antidepressant treatment reduced the chances of relapse by 70 % compared to discontinuation of treatment. In addition, the effect of the treatment persists for up to 36 months. Recently, it was discovered that the drug ketamine has rapid antidepressant effects in patients with depression, because it blocks synaptic transmission that leads to the activation of various signaling pathways and increases the expression of neurotrophins, as a result, there is greater plasticity in the prefrontal cortex and hippocampus, allowing the restoration of these areas.

Drug therapy can have serious side effects, including increased suicidal thoughts and behaviors, as the Food and Drug Administration (FDA) warns. It is also not possible to ignore the dependence, tolerance (Targum, 2014) and withdrawal symptoms, which the patient can develop when taking them for long periods of time, becoming a risky alternative, with an effectiveness of approximately 40-60 %; several patients abandon treatment or resort to constant change of doctor, risking their physical and mental health.

In the case of Pediatric Psychiatry, doctors face several challenges when considering antidepressants for their patients, since there are problems in tolerability and safety in their development and growth. The evidence base in Child Psychiatry it is lower compared to adult psychiatry; likewise, the relevant research for these drugs to be approved by federal agencies is conducted (mainly) in adults. But, over the last decade, the use of antidepressants in children and adolescents has increased in many western countries. From 2005 to 2012, the prevalence of antidepressant use increased from 1.3 % to 1.6 % in the US; from 0.7 % to 1.1% in the UK; from 0.6 % to 1.0 % in Denmark; from 0.5 % to 0.6 % in the Netherlands; And from 0.3 % to 0.5 % in Germany (Bachmann, 2016). Despite this increase, the efficacy and tolerability of antidepressants for severe depression (MDD) in young people continues to be challenged, due to the “black box warning” issued by the FDA in October 2004, warning of increased risk of suicidal

behavior among children treated with SSRIs, therefore, it is urgent to find an alternative treatment that does not put the mental health of pediatric patients at risk (Dwyer and Bloch, 2019; Friedman, 2014; Hernández-Otero *et al.*, 2017).

Another major concern that the medical profession has when prescribing antidepressants to pediatric patients, is the effect they can have in the long term. For this reason, Stutzman (2021), studies the consequences of long-term use of antidepressants in children and young people. For example, antidepressants may be associated with reductions in bone growth and mineral density after long-term use. Weight gain and risk of type 2 diabetes mellitus have been proposed. Children are also at higher risk for cardiometabolic side effects associated with second-generation antipsychotics compared with adults, including the development of type 2 diabetes.

Other proposed long-term risks include reduced bone mineral density and hyperprolactinemia. For example, the use of Divalproex in young women should potentially be avoided, given the risks of polycystic ovary syndrome, weight gain, reduced bone mineral density, and teratogenicity. Maintenance treatment studies suggest that lithium is safe, with close control of thyroid function, kidney function, and serum concentrations. However, ongoing assessments are needed to understand clinical interventions and implications for adulthood.

As an alternative to, or to support drugs, clinicians may prescribe transcranial magnetic stimulation (TMS) (Nguyen and Gordon, 2015). A non-invasive method of inducing a focal current in the brain and altering the function of the target cortex. The therapy is based on Faraday's electromagnetic induction principles and was declared as a method to induce currents in the human brain in 1985 (Barker *et al.*, 1985).

They also explain Barker *et al.* (1985), that the electrical potential associated with this brain current allows the depolarization of neurons in the motor cortex, and generates an evoked motor potential (MEP or MT). This is possible by applying magnetic pulses generated by a coil placed over the patient's head. Such pulses create a magnetic field capable of crossing the scalp and skull, allowing the induction of a current in the brain to stimulate neuronal tissue in a non-invasive, painless and without the need for anesthesia. Specifically, in patients with depression, it serves as a brain intervention that modulates gabaergic and glutamatergic cortical imbalances in a non-invasive manner, without moderate or severe side effects, and completely ambulatory. By

directing high-frequency stimulation to the left dorsolateral prefrontal cortex (DLPFC), glutamine/glutamate ratios in the anterior cingulate cortex and the left dorsolateral prefrontal cortex are increased, proving its effectiveness in modulating glutamate neurochemistry in depressed adolescents.

It was Pascual-Leone *et al.* (2000) who demonstrated that it has effects on perception and cognition by means of "virtual lesions", but repetitive pulses of TMS, or repetitive transcranial magnetic stimulation (rTMS), were first demonstrated. As an effective therapeutic modality for major depressive disorder (MDD) in the mid-1990 (George and Wassermann, 1994; George *et al.*, 1995; Pascual-Leone *et al.*, 1996) and, over the past two decades, it has been repeatedly shown to have a therapeutic benefit for MDT (George *et al.*, 2000, 2010; Dannon and Grunhaus, 2001; Grunhaus *et al.*, 2002, 2003; Prudic etal., 2004; O'Reardon *et al.*, 2007; Slotema *et al.*, 2010; Barredo, 2021; Bozzay, 2020). The long-lasting effects of rTMS on mood are consistent with the observed effects of repetitive stimulation on brain function. It has been reported to last minutes to days after completion of stimulation and extends far beyond the stimulation site, suggesting sustained effects on the excitability and plasticity of neural circuits (Siebner and Rothwell, 2003).

It is important to emphasize that the treatment of TMS, even considered as safe and without severe or moderate side effects in the long or medium term, has ethics and safety guidelines so as not to expose the patient to danger. In medicine, it is common to resort to a treatment consisting of a drug device, referring to the interaction that occurs between a prescription drug and a medical device. This may also be known as augmentative therapy: when two different treatments combine to increase the effects of the first treatment. In the case of TMS and medicines, TMS is recommended to increase the effects of a previously prescribed antidepressant (Berlim *et al.*, 2011).

Liu *et al.* (2014), analyzed seven clinical trials that included simulated augmentative TMS treatment (placebo) and active TMS augmentative therapy. All participants in the studies had previously taken a course of antidepressant medication with no improvement in mood. The researchers compared patients who received active TMS treatment versus simulated TMS treatment, and concluded that active TMS therapy significantly increases the effects of antidepressant medication, compared with simulated TMS treatment.

Another study published by Rumi *et al.* (2005), demonstrated a significant accelerated impact on the effects of amitriptyline during treatment with TMS. Over the course of four weeks, patients received either simulated or active TMS treatment, in addition to taking amitriptyline: they found that patients improved more rapidly with medication and TMS than with antidepressants alone.

This research seeks to examine the effect on the mood that the therapy has in adolescent patients with depression, receiving 30 sessions of repetitive transcranial magnetic stimulation, carried out in six weeks, 15 Hz to 100 % of the motor threshold with 3000 pulses per session applied to the left dorsolateral prefrontal cortex (LPFC), to declare it as an effective alternative for patients with depression.

Metodology

Design

The research was carried out with two groups: the experimental group formed by ambulatory patients in pharmacological treatment (N=6) who received 30 sessions of open-label TMS (experimental group), and the control group consisting of patients with depression in pharmacological treatment (N=6) who did not receive TMS. Using the Hamilton Depression Scale (HDRS), disease severity and progression were monitored in all participants in the same time periods (Christensen *et al.*, 2005). These scales provide quantifiable measures that we can contrast to answer the question: is TMS an effective therapy to treat juvenile drug-resistant depression?

The research design is experimental, because it allows comparing the two interest groups with an independent variable and a dependent variable:
- Independent Variable (VI): receive treatment TMS.
- Dependent variable (VD): result of RCD-R and RSD.

Participants

The sample for this research is non-probabilistic; however, you must have the following criteria to be included or excluded from both the control and experimental groups:
- Female and male adolescents;
- Diagnosis of juvenile depression by psychologist or doctor;

- Ages from 14- 18 years;
- At least one year of diagnosis with depression;
- Drug intervention (antidepressants);
- Without history of epilepsy;
- Female participants not pregnant;
- Without tattoos on the neck, face or head;
- Without metal implants on the neck or head; and
- Without heart problems.

Instruments

To run the study, patients underwent the Hamilton Depression Scale (HRSD), (Hamilton, 1960) which, since the 1970, became the dominant tool for assessing the severity of depression. A key feature of HRSD is that it was initially used to measure the outcome of treatment, especially drugs, and was applied as a "before and after" scheme, so it is appropriate to assess the severity of depression during research.

Likewise, the revised Childhood Depression Rating Scale (CDRS-R) was used (Mediano Cortés *et al.*, 2021; Mayes *et al.*, 2010) for the same purpose, both based on scores. To perform TMS treatment, The Horizon Performance system gives the opportunity to treat more patients by offering greater cooling capabilities, efficiency and versatility. In addition, it has a patented energy recovery system that ensures constant dosing during a treatment session, and the Horizon EZ-Arm provides safe and effortless coil positioning that provides the best comprehensive TMS system in its class (Introducing Horizon® Performance - Magstim TMS Therapy, 2018).

The D70 Air Film Coil (AFC) was chosen as the coil, which is air-cooled creating a focal magnetic field and powerful temperature cooling for a variety of research applications. The AFC ventilator allows minimal downtime between the execution of high intensity protocols, such as high frequency repetitive pulse protocols (Dargavel, 2021).

Likewise, it is eight-shaped, so the induced electric fields flow in the brain, forming two vortices that merge at the center of figure eight. In this way, we can provide localized and focal brain stimulation (Ueno *et al.*, 1988, 1990). Computer simulations

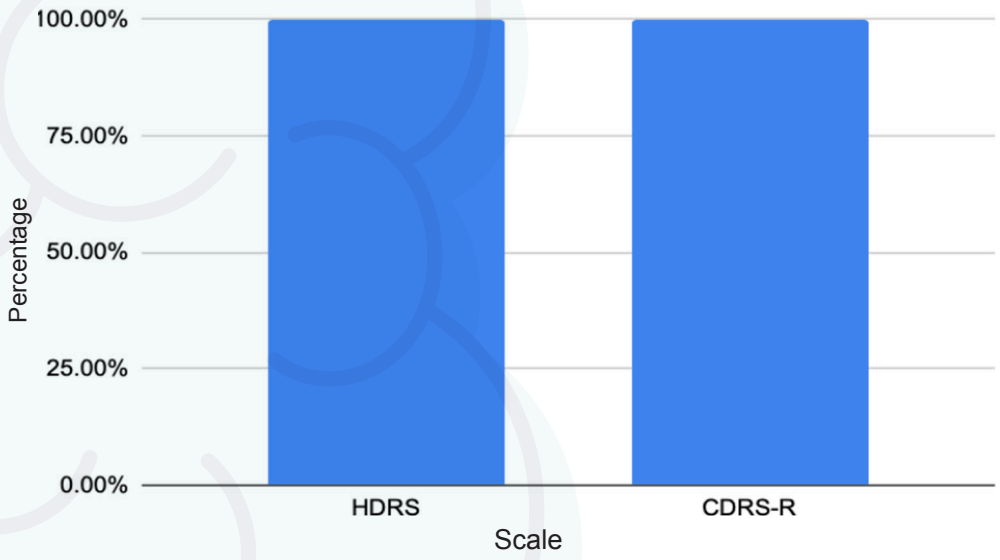
show that the electric fields in the target are three times higher than those in the non-target areas with such a coil (Ueno and Sekino, 2021).

Results

The study involved six patients aged 14 to 18 years with drug-resistant depression who underwent drug therapy by a psychiatrist. Two questionnaires were completed by 100 % before the study: HDRS and CDRS-R as a reference point and follow-up to disease progression during the study.

Figure 1

Percentage of participants who completed the HDRS and CDRS-R scales.

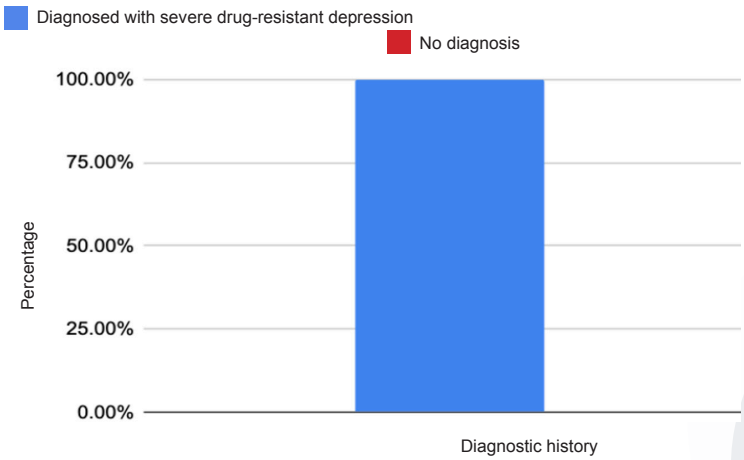


Note: percentages in relation to valid questionnaires received at the date of data receipt.
Source: own elaboration.

To join the study, participants had to be diagnosed with severe drug-resistant depression, in this case, 100 % met the criteria.

Figure 2

Percentage of participants diagnosed with severe drug-resistant depression.



Note: percentages in relation to valid questionnaires received at the date of data receipt.
Source: own elaboration.

It was mentioned earlier that participants underwent two assessments. The first with the Hamilton Depression Scale that qualifies all participants in the control group (n=6) as severe depression (score >17) (μ=36.33, σ=6.28). This result is confirmed by the qualification of the same participants in the CDRS-R (μ=79.33, σ=6.56), (Table 1).

Table 1

Ratings, mean and standard deviation of the scales: HDRS and CDRS-R.

Subject	Hamilton rating	Interpretation	CDRS-R rating
1A	46	Severe depression	94
2A	45	Severe depression	83
3A	40	Severe depression	77
4A	24	Severe depression	69
5A	33	Severe depression	80
6A	35	Severe depression	65
MEAN	37.17		79.33
STDV	8.28		10.35

Note: ratings in relation to valid questionnaires received at the date of data receipt.
Source: own elaboration.

The participants were again subjected to the same scales to record the evolution of the disease, after three weeks of pharmacological treatment.

According to the data obtained and the results of the paired t-test, it is considered that the difference in depressive state during this period is not statistically significant in any scale: HDRS (p = 0.36, t = 1.00) with a confidence interval of 95 % of this difference: from -1.79 to 0.79; and the CDRS-R (p= 0.59, t=0.57), with a confidence interval of 95 % of this difference: from -2.35 to 3.68 (Table 2).

Table 2

Ratings, mean and standard deviation of the scales: HDRS and CDRS-R of control group, after three weeks.

Subject	Hamilton rating	Interpretación	Calificación CDRS-R
1A	43	Severe depression	91
2A	42	Severe depression	81
3A	38	Severe depression	80
4A	26	Severe depression	72
5A	33	Severe depression	76
6A	36	Severe depression	76
MEAN	36.33		79.33
STDV	6.28		6.56

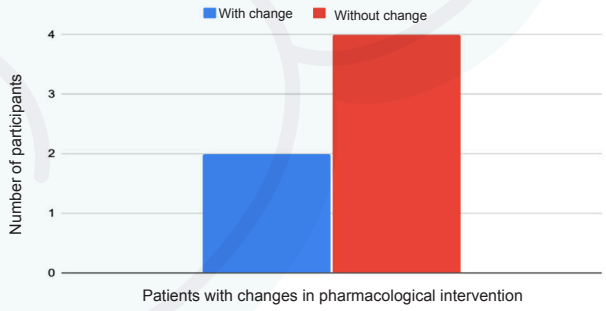
Note: ratings in relation to valid questionnaires received at the date of data receipt.
Source: own elaboration.

It is important to note that antidepressants, during this period of time, bring with them non-tolerant side effects that would put at risk the physical and mental well-being of the patient, so it is not uncommon for them to be modified.

This was the case for two of the participants who will take longer for the drugs to have a positive effect on their mood.

Figure 3

Number of participants whose pharmacological intervention was modified.



Note: amounts in relation to valid questionnaires received at the date of data receipt.
Source: own elaboration.

After six weeks, it would be expected that the therapeutic effect of antidepressants would begin, therefore, at this time, the development of the disease in participants was again evaluated using the same scales. According to the conventional criteria, the therapeutic effect of antidepressants is considered not statistically significant on any scale, according to the paired t-test: HDRS (p = 0.0747, t = 2.25) with a confidence interval of 95 % of this difference: from -1.59 to 23.59; and CDRS-R (p= 0.086, t=2.14), with a 95 % confidence interval of this difference: from -4.17 to 45.17 (Table 3).

Table 3

Ratings, mean and standard deviation of the scales: HDRS and CDRS-R of control group, after six weeks.

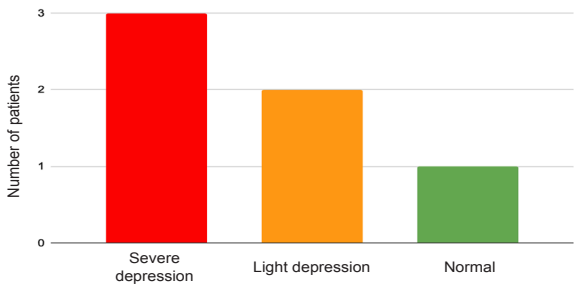
Subject	Hamilton rating	Interpretation	DRS-R rating
(6 weeks)	Interpretation	Qualification	91
CDRS-R	42	Severe depression	81
1A	45	Severe depression	91
2A	16	Mild depression	57
3A	37	Severe depression	78
4A	6	Normal	12
5A	14	Mild depression	43
6A	34	Severe depression	72
MEAN	25.33		58.83
STDV	15.41		28.36

Note: ratings in relation to valid questionnaires received at the date of data receipt.
Source: own elaboration.

However, 50 % of patients had an improvement in their mood due to pharmacological intervention: based on the interpretation of the Hamilton test, all participants qualified with severe depression and, after six weeks, this score changed in half of the participants.

Figure 4

Interpretation of HDRS rating in control group after six weeks.

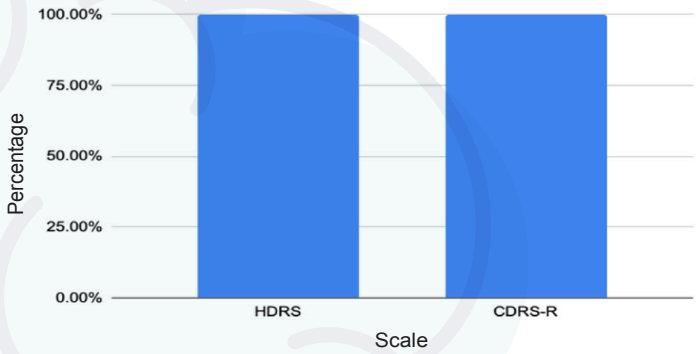


Note: amounts in relation to valid questionnaires received at the date of data receipt.
Source: own elaboration.

For the experimental group (group B), we had the participation of six patients in the same age range, with drug-resistant depression, who underwent pharmacological treatment by a psychiatrist and transcranial magnetic stimulation. All completed the HDRS and CDRS-R questionnaires prior to the study with the same goal of assessing disease development during this time.

Figure 5

Percentage of participants in experimental group who completed HDRS and CDRS-R scales.

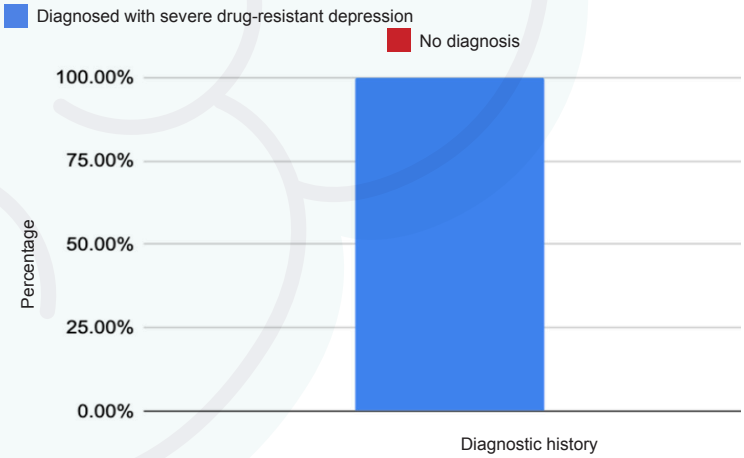


Note: percentages in relation to valid questionnaires received at the date of data receipt.
Source: own elaboration.

To participate in the study, participants had to be diagnosed with severe drug-resistant depression by a psychiatrist, and be within the established age range. 100 % met the criteria.

Figure 6

Percentage of participants diagnosed with severe drug-resistant depression.



Note: percentages in relation to valid questionnaires received at the date of data receipt.
Source: own elaboration.

As Table 4 shows, the Hamilton Depression Scale rates all participants (n=6) with severe depression (score >17) (μ=35.50, σ=6.95). This result is supported by the qualification of the same participants in the CDRS-R (μ=76.17 σ=5.81), (Table 4).

Table 4

Qualifications, mean and standard deviation of the scales: HDRS and CDRS-R of experimental group, pre-treatment.

Subject	Hamilton rating	Interpretation	DRS-R rating
1B	36	Severe depression	79
2B	42	Severe depression	81
3B	23	Severe depression	75
4B	33	Severe depression	65
5B	38	Severe depression	79
6B	41	Severe depression	78
MEAN	35.50		76.17
STDV	6.95		5.81

Note: ratings in relation to valid questionnaires received at the date of data receipt.
Source: own elaboration.

The experimental group underwent 30 transcranial magnetic stimulation (TMS) sessions, distributed in six weeks, five days a week, consisting of 3000 high frequency (HF) pulses per day, respecting the protocol established as safe and efficient (Bakker *et al.*, 2015). Participants took the same scales again to record disease progression. After three weeks of five weekly sessions, consisting of 3000 high frequency (HF) pulses daily, they obtained the scores shown in Table 5.

The mean of the control group (A) minus the experimental group (B) is equal to 12.33, and according to the results of the paired t-test, it is considered that the difference in depressive state during this period is statistically significant in both scales: HDRS (p = 0.0129, t = 3.78) with a confidence interval of 95 % of this difference: -3.95 to 20.72; and the CDRS-R (p = 0.0057, t = 4.6351), with a confidence interval of 95 % of this difference: -2.35 to 3.68.

Table 5

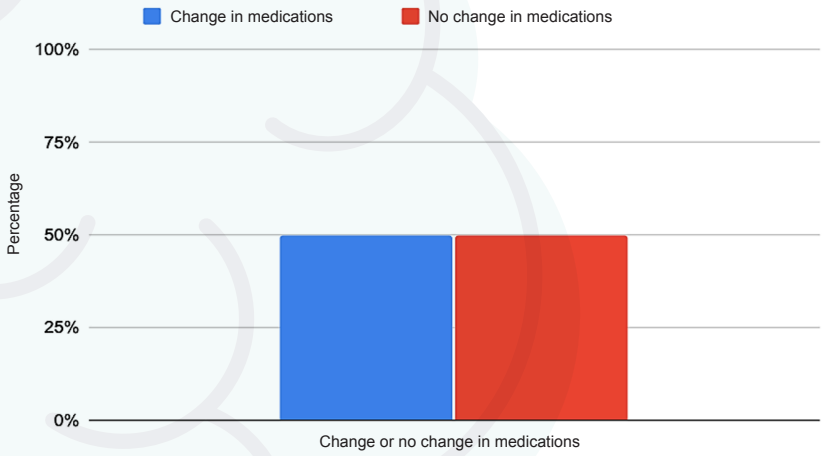
Ratings, mean and standard deviation of the scales: HDRS and CDRS-R of control group, after 15 sessions.

Subject	Hamilton rating	Interpretation	C DRS-R rating
1B	25	Severe depression	57
2B	18	Severe depression	54
3B	16	Severe depression	56
4B	16	Severe depression	47
5B	24	Severe depression	45
6B	40	Severe depression	76
MEAN	23.17		55.83
STDV	9.13		11.02

Note: ratings in relation to valid questionnaires received at the date of data receipt.
Source: own elaboration.

Figure 7

Percentage of patients who switched medications during TMS treatment.



Note: percentages in relation to valid questionnaires received at the date of data receipt.
Source: own elaboration.

Finally, after six weeks of TMS and pharmacological treatment, the patients completed the scales for the last time and, according to their ratings, their mood improved considerably to such an extent that two of the six participants did not present depressive symptoms at the end of treatment (Table 6 for results of the scales after six weeks of TMS and pharmacological treatment).

Table 6

Ratings, mean and standard deviation of the scales: HDRS and CDRS-R of control group, after 30 sessions.

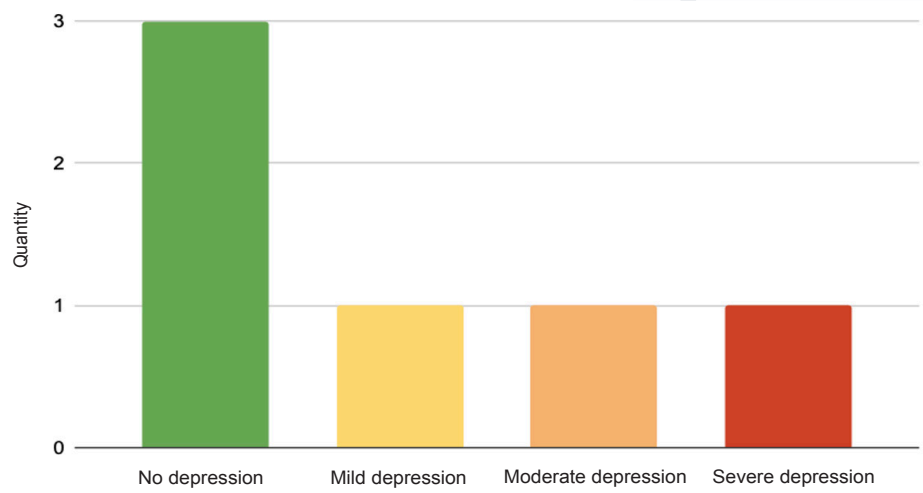
Subject	Hamilton rating	Interpretation	CDRS-R rating
1B	9	N/A	26
2B	8	N/A	22
3B	9	N/A	25
4B	11	Mild depression	43
5B	16	Moderate depression	42
6B	40	Severe depression	77
MEAN	15.50		39.17
STDV	12.34		20.61

Note: ratings in relation to valid questionnaires received at the date of data receipt.
Source: own elaboration.

The P-value of two tails is equal to 0.0077 (p=.0077, t=4.2967), which, according to conventional criteria, is considered very statistically significant. The mean of pre-treatment minus post-treatment ratings in the experimental group is equal to 20.00, with a 95 % confidence interval of this difference: from 8.03 to 31.97.

Figure 7

Interpretation of the HDRS rating in the experimental group after post-treatment.



Note: percentages in relation to valid questionnaires received at the date of data receipt.
Source: own elaboration.

Discussion

This study included a sample of 12 participants between the ages of 14-18 years, all residents of San Salvador and La Libertad. The participants were divided into two groups of equal proportion: six in the control group and six in the experimental group. All patients had to be diagnosed with severe drug-resistant depression for at least one year (Pignone *et al.*, 2002).

A statistical analysis was performed comparing the means of the t-matched tests in three different stages: at the beginning of the experiment, three weeks after the experiment (or TMS treatment if they belonged to the experimental group) and at the end of the six weeks. According to the results, the hybrid treatment has faster positive effects on mood when compared to the exclusive treatment with drugs. However, there are several points that must be taken into account and must be discussed; for example, it is important to mention that, in the clinic, drug treatment is based on trial and error, which means that, if an antidepressant has no positive effect on a mood, it does not mean that there is no other that can have it.

Therefore, it cannot be based on this study alone to dictate that drug treatment as a single resource is not as effective or more effective than hybrid treatment. In many cases, the patient is diagnosed with drug-resistant depression; however, the reality is that finding the right drug can take years, and it would be considered fairer to compare the outcome of the hybrid treatment versus the right drug.

According to guidelines from the American Psychiatric Association, if the patient is taking an antidepressant to treat their first depressive episode, they should continue taking it for at least four to five months after the symptoms of depression disappear, keeping in mind that you may need to try several different antidepressants to find the right option for the patient, and even, then, it may take two or three weeks to see an initial improvement. After that, it may take three to six months until symptoms improve to the point that you are no longer depressed. In short, this could mean taking a prescription for about a year to get all the benefits (Crist, 2021).

This would be a scenario in which drugs would be a tolerant, efficient alternative that provided the desired results, but it should be considered that, in a large percentage of cases, this is not the result because, as mentioned by Willner *et al.* (2013), "a

treated brain is not 'normal'". However, in the case of severe depression, patients do not have many years to experiment with various medications, so it is better to opt for a personalized treatment that produces effects in a short period of time such as transcranial magnetic stimulation.

In addition, the emotional and economic wear and tear on medical appointments and on the same medications that most patients with severe depression or drug-resistant consume for long periods of time must be taken into account. In this attrition, patients tend to change doctors if the pharmacological intervention does not offer the relief it promises, in this sense, the change of doctor can be counterproductive. Because of this, considering the option of a treatment that provides the relief the patient seeks more quickly and effectively is crucial.

It is important to note that antidepressants, during this period of time, can bring with them non-tolerant side effects that put the physical and mental well-being of the patient at risk, so it is not common for these to be modified. This was the case of two participating patients, who will take longer for the drugs to have a positive effect on their mood.

However, in order to measure the effectiveness of a treatment, relapse must be taken into account, which in patients with severe depression is not uncommon. In patients receiving TMS, Mantovani *et al.* (2012) reported a three-month relapse rate of 13.5 %, and Cohen *et al.* (2009) reported that 60 % of patients remained in sustained remission three months after completing a course of TMS, although this amount decreased to 22.6 % after six months. However, relapse can be prevented with maintenance sessions and disassociation of therapy. The disadvantage is that there is no established protocol for this stage, and, therefore, it must be carried out by the judgment of the trafficker (Cristancho *et al.*, 2013).

The TMS Clinical Society answered the following question in a survey: "Approximately what percentage of your patients relapse after successful TMS treatment over a one-year period?" The answer was that 128 suppliers with 35.94 % supported a relapse of 16 to 30 %; 25.78 %, reported a relapse of 0 to 15 %; and 22.66 %, a relapse of 31 to 45 %. For antidepressant medications, the relapse rate is approximately 50 % 12 months after stopping treatment; however, the percentage varies depending on the period of treatment.

The study shows that, after six weeks, 83 % of patients felt an improvement in their mood and 66 % no longer qualified as a patient with depression (according to the Hamilton Scale). On the other hand, in the control group, 50% obtained an improvement in symptoms and only one patient qualified as non-depressive. The TMS not only evidences its effectiveness, but also proves to have an effect on the patient's mood in a shorter period of time than antidepressants; All of the above, supported by the experiment, magnetic stimulation hopes to cause a positive effect on depressive symptoms after three weeks or 15 sessions.

Added to this, at three weeks, half of the patients in the experimental group changed medications (Figure 7) as a result of the improvement in mood, responding to lower doses, unlike the control group, whose changes were attributed to the negative side effects caused by the drugs. Finally, an important point is the cost-effectiveness of repetitive transcranial magnetic stimulation versus antidepressant therapy for treatment-resistant patients: Nguyen and Gordon (2015) proved the superiority of TMS in terms of value for money compared to antidepressant medications.

In conclusion, TMS proved to be a rapid, effective and non-invasive treatment that can alleviate symptoms of depression in conjunction with pharmacological treatment. Unlike medications, TMS does not cause side effects and can lead to short- or long-term reduction and/or elimination.

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An experiment on ideological vulnerability

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SUMMARY

From the perspectives of Experimental and Social Psychology, this study based on an experiment attempts to answer the question of ideological vulnerability, that is, how robust or vulnerable systems of ideas are in the face of seven hypothetical frameworks: money, sex, power, religion, crisis, fear and power. In this experiment, one of them was addressed, money. The results of the experiment indicate that ideological systems are vulnerable; however, this academic exercise cannot be generalized for statistical reasons: it rather represents an exercise to approach the problem.

Keywords: Social Psychology, Experimental Psychology, ideology.

Introduction

The starting point of this research is based on two aspects: a) From the methodological point of view, the tradition of Experimental Psychology (Slater, 2014); and b) The principles of Social Psychology defined by Martín-Baró (1976):

> Social psychology must, therefore, clarify the impact that the presence of people has on certain tasks of the individual, that is, to what extent, which, how and why their actions are influenced by the presence of others. This means that the very action of the subject implies an essential relationship to others, and it is this relationship that Social Psychology has to clarify (...) The relational aspect is not something generic or abstract in behavior, but something very concrete: it is this, that or the other relationship with this or that person, under this or that characteristic, with this or that meaning (...) In this sense, Social Psychology tries to find the references between each behavior and each society, that is, this behavior as social and this society, as acted in concrete behaviors (...) In short, Social Psychology is a hinge science, whose purpose is to show the connection between two structures: the individual structure (the human personality and its consequent task) and the social structure (each historical society), or, in other words, to show the double reality of the individual in society and of society in the individual (...) **In the light of this analysis, we can affirm that the specific object of Social Psychology is the study of ideology.**
>
> Precisely ideology is constituted by those psychological processes that determine the concrete way in which individuals live (think, feel, act), but whose adequate explanation is not found in individuals, but in group reality and in the way in which the individual is inserted into social groups in a certain historical situation (...) An ideology is a system (which has its own logic and rigor) of representations (images, myths, ideas or concepts as the case may be), endowed with a historical existence and a historical role within a given society (...) Ideology is first and foremost a series of vital (psychosocial) schemes in which and through which individuals give shape and meaning to their concrete existence. (pp. 19-21).

In summary, and from the experimental approach of Martín-Baró (1976), the study also aims to obtain information to:

Explain psychosocial processes, their causality, their aspects, etc. For example, the psychological processes that lead to adopt a certain political attitude, to vote for a certain candidate, to participate in a certain demonstration or to run a certain "gossip".

Predict the behaviors of individuals and groups. The understanding of psychological processes and their causes allows us to predict what will be the behavior that, in each situation, individuals are most likely to observe. Thus, for example, predicting in what conditions and circumstances and what type of individuals will vote for this or that candidate, how a demonstration can evolve in the face of one or another circumstance (police intervention or not), what public reaction can trigger such a type of "gossip", etc.

Control behaviors. It is the goal of all science: to acquire control over processes, in this case, over social processes. This control should not be understood as something mechanical and less in something as complex as human behavior. We speak of control in the sense of being able to guide and promote behaviors considered socially more constructive and profitable and modify those considered socially harmful. Thus, for example, preventing or predicting the appearance of inappropriate or future behaviors, and directing social groups towards more profitable activities. (pp. 24-25).

Now, it is obvious that, like all experimental science, the present study has a series of limits that it is important not to lose sight of. One of the most serious limits is its ethical conditioning on the use of subjects to act in fictitious scenarios, depending on the facts accessible in each case and circumstance to the investigation. Other methodological limitations will have to do with issues related to the dynamics of experimental work depending on the availability of the subjects.

A background: on "social humor"

As of the date of this research, we have conducted three surveys on "Social and political humor: cosmovision and ideology"[1], which have provided important

1 First study: https://www.disruptiva.media/el-humor-social-y-politico-cosmovision-e-idologia-de-los-salvadorenos/
Second study: https://www.disruptiva.media/2a-encuesta-humor-social-y-politico-de-los-salvadore-

statistical data on the idiosyncrasy and Salvadoran belief system. Social psychology seeks to study, understand, and explain how individual thoughts, feelings, and behaviors are influenced by real, symbolic presence, or implicit of other human beings. On the other hand, humor is a disposition, or expression of a subject's mood. So, can there be a social mood? Can a certain phenomenon influence people's mood? and finally: can people act politically or vote influenced by this social mood? (Picardo, 2020).

Social mood[2] can be defined as the mood (optimistic or pessimistic) of a dominant community or society, in a given context or at a given time. This social mood is formed by the interaction of individuals (Spivak, 2015). Based on this circumstance, reality and information are perceived, processed and interpreted, and affect the decisions made in terms of acceptance or rejection of communication, the way of living and aspirations. It tends to significantly influence the opinions, attitudes, positions of phenomena, institutions and characters.

In the literature review, no further background information on books has been found or refereed articles related to social humor, except for a contribution by Dr. Marjolein 't Hart: "Humour and social protest: an introduction" (Marjolein 't Hart, 2007); the rest are research on humor and communication (Segado-Boj, 2011), typology of humor (Cantero García, 2020), discourses on humor (Cabral Scabin, 2020), among others. There are some references that have been consulted, but not cited, also listed in the bibliographic references.

Social behavior, on the other hand, are collective, widespread and contagious ways of acting, based on cohesion, rumors, beliefs and shared values. Indeed, before we called them "mass phenomena", today they are also classified as "springs". Thus, the subjects lose their individuality and act as a herd, as if they were infected, following trends -hashtags-.

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nos-paradigmas-y-creencias/
Third study: https://www.disruptiva.media/iii-encuesta-de-humor-social-y-politico/

2 It is the state of mind that predominates in society, depending on it reality is perceived and information is filtered and interpreted. It impacts on the decisions that are made, in the purchase of goods, in the acceptance-rejection of communication, in the way of living, in the goals and desires that are established. It prevails and significantly influences attitudes, positions and evaluations of issues, institutions and characters exposed to public opinion (NODO, 2021, para. 1).

The analysis of social mood and social behavior is a subject that can be dealt with by biologists, mathematicians, anthropologists, sociologists and social psychologists. It involves a holistic analysis based on data, usually provided by surveys and sectoral studies.

We start from a fundamental methodological principle to understand humor and social behavior: compartments or classes. In Latin American societies there have been three large socioeconomic demographic blocs that have different paradigms, moods and different behaviors: a minority with life resolved, a second minority in a process of social ascent, and a majority in serious problems of survival. This has traditionally been classified as rich, middle class and poor.

Social networks caused a particular phenomenon: they disconnected the articulating elements between the three demographic blocks. In the past, the dominant classes generated a phenomenon of dependency that immobilized the mood and behavior of the underlying groups, through structures of domination (education, employment, culture, etc.); now hyper-democratized social networks of information, causing an independence of thought and a fractal phenomenon.

Starting from the principle that voting is an emotional decision, in electoral matters in the past four elements influenced decision-making to cast the vote: tradition, propaganda, trends and fear; these elements shaped mood and electoral behaviors. Currently, in the information society (Castells, 1999), there is a new networked logic; through the web and its platforms or social networks, other information nodes have been created that influence decisions, and modify mood and behavior.

Social networks have accelerated the process of the "relativization of everything": no longer depend on classical authority (business, religious, academic, etc.), because it is the image, the short texts or Twitter, the fakenews, the influencer on YouTube, which mobilize the new truths, creating other moods and behaviors. Symbols have also changed: they are digital and liquid (Bauman, 2004), therefore volatile, dynamic and ephemeral.

The relativization of everything implies an axiological subversion; now, disdain, insult, rudeness and disruptive use of authority are above other values that were well seen, but were not effective. Indeed, the honesty and ethics of the past were not genuine,

because it allowed and enabled corruption. The new mood and social behavior has given the opportunity to new strident speeches.

Ideology: what are we talking about?

The concept ideology was formulated by Antoine Destutt de Tracy (in Mémoire sur la faculté de penser, 1796), and originally called a the science that studies ideas, their character, origin and the laws that govern them, as well as the relations with the signs that express them.

Half a century later, the concept embraces its current meaning by being associated with an epistemological perspective, founded by Karl Marx and Friedrich Engels in their work "The German Ideology" (1974). For these authors, ideology is the set of principles that explain the world – or conceal interests – in each society according to its modes of production, relating the practical knowledge necessary for life with the system of social relations. The relationship with reality is very important to maintain these social relations, and in social systems in which some kind of exploitation occurs to prevent the oppressed from perceiving their state of oppression.

In his celebrated "Prologue to the contribution to the critique of political economy," Marx (1859) writes:

> The sum total of these relations of production forms the economic structure of society, the real basis on which the juridical and political superstructure is built and to which certain forms of social consciousness correspond. The mode of production of material life conditions the process of social, political and spiritual life in general. It is not man's consciousness that determines his being, but, on the contrary, it is the social being that determines his consciousness. (para. 2)

So, we speak of ideology when a set of determined ideas, interpreting the real, are considered as true and are widely shared consciously by a social group in a given society. Such ideas become a strongly identity trait, similar to religion, nation, social class, sex, political party, social club, etc., and form both small and closed groups and sects or larger or open groups.

The origin of most ideologies is usually found in philosophical currents. The first philosophers to study "ideology", the french psychologists (Condillac, Cabanis,

Destutt de Tracy), placed this need in the "inner self", interpreted in various ways (psychologism and psychophysiologism). The subject is opposed to the external, which occurs as an event, since it requires individual reflection. These french thinkers intended to structure a theory on the primitive materialism of sensations and hence its derivation into emotions, passions and feelings, so that, from the fact, the event or the external event, one passed psychologically to the inner way of grasping things and appreciating these categories of personal psychology.

From Social Psychology, an ideology is a normative set of emotions, ideas and collective beliefs that are compatible with each other and are especially related to human social behavior.

Ideologies are usually described and postulated in ways of acting on the collective reality, either on the general system of society or in one or more of its specific systems, such as economic, social, scientific-technological, political, cultural, moral, religious, environmental or others related to the common good. Most scholars on the subject define **ideology as a system or universe of values or set of ideas that reflect a conception of the world or worldview, codified in a doctrinal body, with the aim of establishing channels of influence and justification of their interests of the social or political group that sustains it.**

Ideologies usually consist of two components, one theoretical and one practical: a representation of the system and a program of action. The representation provides its own and particular point of view on the current reality, observing it from a certain perspective composed of emotions, perceptions, beliefs, ideas and reasoning, from which it is analyzed and compared with a real or alternative ideal system, ending in a set of critical and value judgments that pose a point of view superior to the current reality. The action programme aims to bring the actual existing system as close as possible to the ideal system intended.

Because of their receptivity to change, there are ideologies that seek the preservation of the system (conservative), its radical and sudden transformation (revolutionary), gradual change (reformist), or the readoption of a previously existing system (restorative). By their origin, scope, and purpose, ideologies can develop gradually through observation, dialogue, education, mutual adjustment, and consensus on what is considered socially correct, deviant, or harmful, or else be imposed (including

through violence) by a dominant group especially interested in generating influence, leadership, or collective control, without distinction whether this is a social group, an institution, or a political, social, religious or cultural movement, or whether its purpose is focused on promoting the common good or a particular interest.

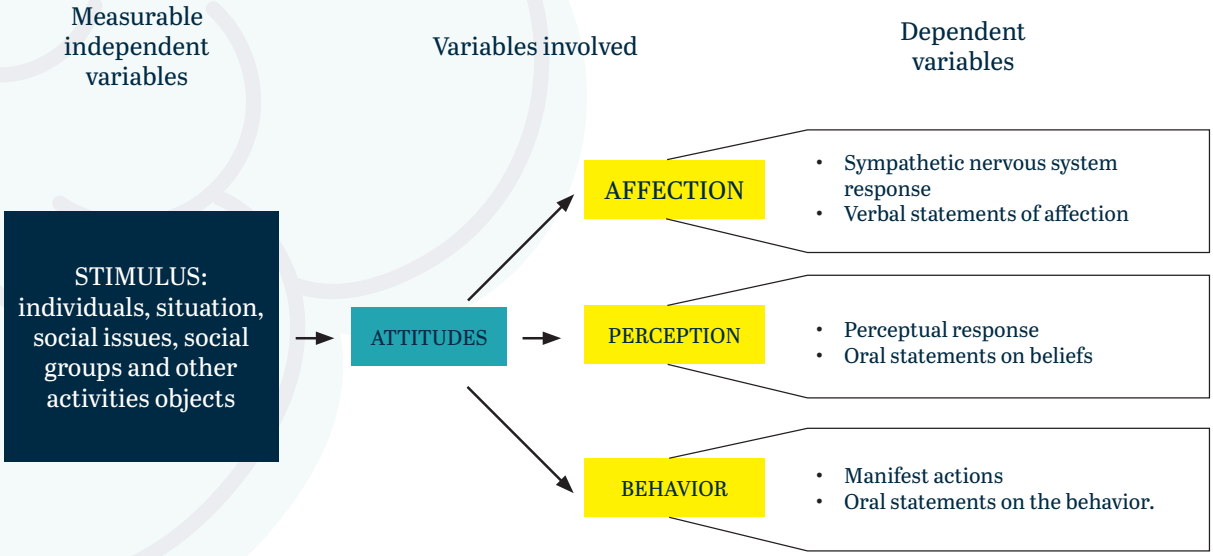
The concept of ideology differs from that of worldview (weltanschauung), in that it is projected to an entire civilization or society, in which case it is related to the concept of dominant ideology, when it encompasses all the specific systems of society and is shared by a large majority of the population. Because of its collective nature, the concept is rarely restricted to the mindset of an isolated or particular individual.

Research model

Citizens' political attitudes are based on a complex set of beliefs, emotional states, and contagious behaviors; These attitudes have an anatomy as a favorable or unfavorable evaluative reaction to something, as a response or as a cognitive posture convergent affective or rational. A multidimensional scheme to understand these attitudes is proposed by Martín-Baró citing Rosemberg and Hovland, as can be seen in the following figure.

Figure 1

Architecture of the study of attitudes.



Source: Martín-Baró (1976) citing Triandis (in Rosember and Hovland).

The proposed study seeks to explore and understand whether attitudes constitute the reactive valuations and tendencies of an individual, in front of the various objects of reality; in addition, if ideology expresses the way in which a group or social class relates to reality: how it grasps objects (perceptual categorization: cognitive component), how it evaluates them (positive or negative evaluation: affective component) and how it acts before them (socially possible and acceptable behaviors: reactive component).

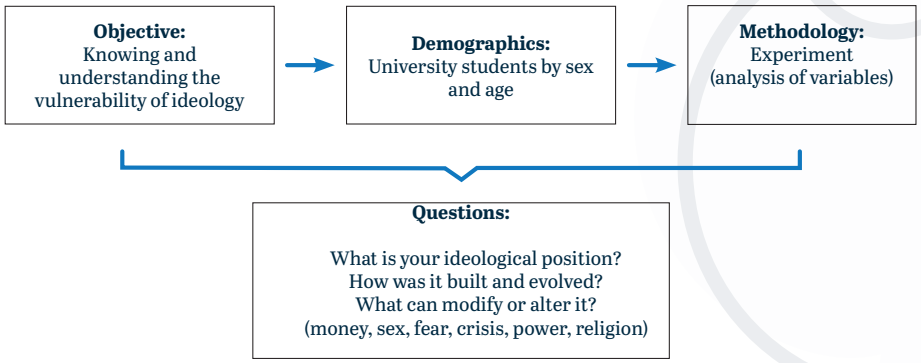
There is also a concern - and a search for an answer - about the relationships between citizens' attitudes, knowledge and opinions; and how propaganda and social media modify these elements.

To achieve these purposes, some psychometric resources were used to measure hypothetical constructs by operationalizing certain variables, considering direction, magnitude, ambivalence, importance, among others.

Finally, in the following figure we propose the model of the study so that the reader has a general idea of the scientific proposal:

Figure 2

Methodological model.



Source: own elaboration.

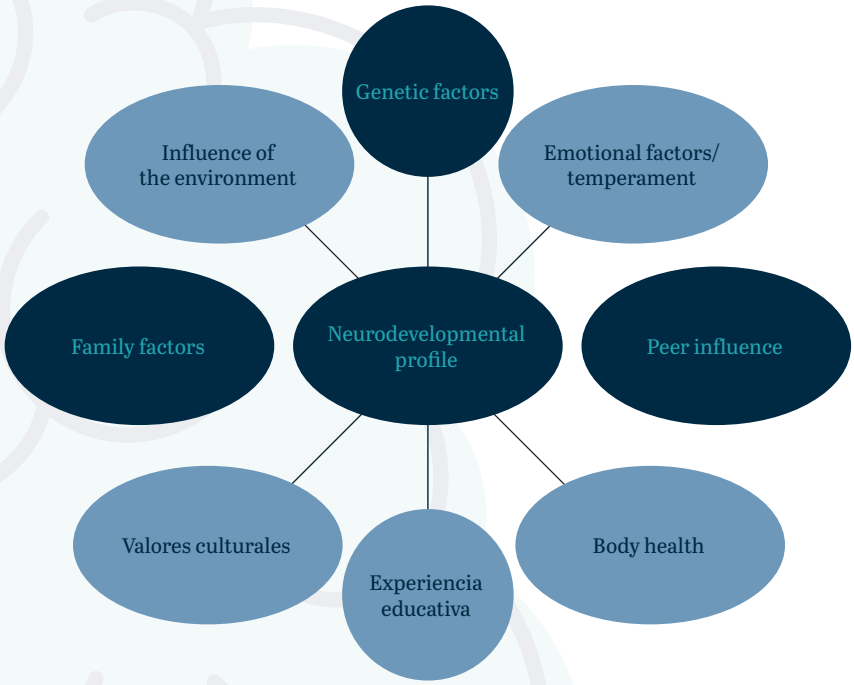
Starting points

Ideology is a set of ideas, beliefs, values and mental representations that guide life, and that have been constructed by the family, the educational system, the environmental context and social interactions.

There are neuroevolutionary profiles and they are not rigid. The ideological or belief system is shaped by various vectors. Genetics, family life and stress, cultural factors, friendships, health, emotions, educational experience and educating society, are the elements that form the mental profile.

Figure 3

Neuroevolutionary constructs or profiles.



Source: own elaboration based on Levine (2003, p. 50)

The theoretical model ABC proposed by the cognitive psychologist Albert Ellis (1913-2007), explains why people, despite living the same event, can develop different responses depending on their own beliefs or systems of ideas. The Ellis ABC model is based on three components of psychosocial adjustment: 1) Activating event; 2) System of beliefs and ideas; and 3) Consequences (Pérez-Acosta *et al.*, 2008).

The activating event ("A"), is that external phenomenon that happens to an individual or that he himself has caused to occur, which causes a series of problematic thoughts and behaviors to be activated. The belief system ("B"), represents the whole series of cognitions (beliefs, prejudices, assumptions, values, etc.), which make up the way of being and seeing the world of the person and to some extent his ideological

apparatus. Finally, the consequences, both emotional and behavioral ("C") in the face of facts or phenomena.

The experiment

The present experimental exercise is brief and starts from the following question: can a person's ideological principles change on the basis of an economic offer?

An email was sent to three groups of students (90 in total), to identify ideological affinity through a temporary job offer of a fictitious marketing and communications company, with a questionnaire (see email in annex).

Once the answers were received, they were classified based on their ideological profile. Then a counteroffer was made doubling the fees, to assess ideological vulnerability.

Table 1

Fictitious offer of temporary employment.

Job offer for university students

We are a regional marketing and communications agency, we are looking for young university students to work on the 2024 electoral campaign in El Salvador doing monitoring in social networks and digital media; our salary offer is US$ 15 per hour, schedule to be agreed, being able to increase the amount and daily hours for special activities; starting on May 15, 2023.

Requirements:

- Be an active college student
- Both sexes (includes LGBTI+ community)
- Have a laptop or mobile phone with an internet connection
- Your political affinity is very important to us, please indicate the following (shade the circle of your choice and mark with red ◯):

What is your ideological profile?	With respect to the current government of President Bukele?
◯ I have no ideology ◯ I consider myself "right-wing" ◯ I consider myself "left"	◯ I am very much in favor ◯ I'm in favor ◯ I am against ◯ I am very much against ◯ I am indifferent
Which political parties could you work for	**Which political parties could you not work with?**
◯ ARENA ◯ FMLN ◯ Nuevas ideas ◯ PDC ◯ Nuestro tiempo ◯ PCN ◯ GANA ◯ Vamos ◯ País ◯ Fuerza solidaria ◯ With everyone	◯ ARENA ◯ FMLN ◯ Nuevas ideas ◯ PDC ◯ Nuestro tiempo ◯ PCN ◯ GANA ◯ VAMOS ◯ País ◯ Fuerza solidaria
If you are interested, submit this complete form to: ProyectoElSalvador2024@gmail.com Full name: DUI Number:	
Program or career in which you are enrolled: University in which you are enrolled: Preferred working hours: On behalf of our team, thank you!!!	

Source: own elaboration.

Results and discussion

Of the 90 submissions, nine complete applications were received (10 % of guests, expected). With seven subjects (five women and two men), it was possible to engage in dialogue and run the experiment. Faced with the counteroffer of money to change their ideological position, five of them answered affirmatively and two simply did not answer.

The evidence is not statistically strong, but the result is strong. None of the subjects participating in the exchange of emails remained in their ideological position, the money factor subdued five subjects and put aside their initial principles in exchange for a possible better pay.

Do we all have a price?

"Every man has his price, what is needed is to know what it is": this famous phrase attributed to the french politician of the eighteenth century, Joseph Fouché, could well continue to be valid today and is at the basis of our experiment.

Frápolli (2013), comments that:

> Neither scientists nor philosophers agree about the characteristics that define our nature, or even about whether there is such a human nature. It is therefore unlikely that the question of whether the penchant for corruption is part of this hypothetical essence can be definitively answered. Fortunately, that answer is neither necessary nor illuminating. That something is part of our nature does not make it acceptable. Perhaps as hominids we are prone to violence, but that does not mean that we should cultivate it. Linking corruption to our nature is still an excuse to eliminate or reduce responsibility. And yet, being responsible for our actions is what makes us rational beings, regardless of what is in our genetic code. (para. 2).

A calm look at what we are, what we do and what we have achieved, can help counteract the effect of cases of ideological vulnerability on the image we have of ourselves. The raw data with which we live every day show that most of us are not willing to betray beliefs or principles in exchange for material goods or social position, but in this exercise there is a new point of view that requires further investigation.

This project seeks to open the door or recover the focus of Experimental Psychology in the Salvadoran academy; it is a first step to continue designing and carrying out scientific exercises that allow us to deepen how we think and how we act.

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Annexe

Example of sent email.