Information and Communication Technologies in Obsessive-Compulsive Disorder

Ricardo Naranjo, Ricardo Valverde, Loïc Martínez Normand

Abstract: The following document is a systematic review regarding the usage of Information and Communication Technologies in Obsessive-Compulsive Disorder (OCD). For this a thorough search in five different online databases until September 2019 was done. A total of 348 articles were found in which duplicates were discarded. After using the inclusion and exclusion properties a total of 21 final published articles since the year 1995 until the year 2018 were left. In the articles the methods to procure the necessary data, the different types of created or used technologies and the outcomes were investigated. Different technologies like databases for tests or researches, controlled environments like virtual environments or physical environments to test reactions or different behaviors, web pages, social media, video games like internet games or virtual reality games and other empirical researches were found. Some interesting suggestions to help both components, meaning Computer Technology and OCD, arose regarding this systematic review for future researches.

Keywords: Obsessive-Compulsive Disorder, OCD, Information and Communication Technologies.

I. INTRODUCTION

OCD or more specifically Obsessive-Compulsive Disorder is a world-wide renown mental illness in the psychiatric area which afflicts a certain percentage of the population [1]. This mental disorder is intrusive and distracting to the point that it can be harmful to the person that carries it, because it interrupts what is considered a normal behavior in society [2], [3]. Computer Science is the science that studies computers and computer systems, different from electrical engineering and computer engineering, this science majorly works with software and software systems; this includes their theory, development and application. It has had such an evolution through the years to the degree that it can be applied to different areas of interest, thanks to being recognized as its own science [4].

Ricardo Naranjo Sánchez∗, Department of Computer Languages and Systems and Software Engineering, Universidad Politécnica de Madrid and Universidad Politécnica Salesiana, Guayaquil, Ecuador. Email: rnaranjo@ups.edu.ec; ricardo.naranjo.sanchez@alumnos.upm.es

Ricardo Valverde, Department of Computer Science, Universidad Politécnica Salesiana, Guayaquil, Ecuador. Email: rvalverdet@est.ups.edu.ec

Loïc Martínez Normand, Department of Computer Languages and Systems and Software Engineering, Universidad Politécnica de Madrid, Madrid, Spain. Email: loic@fi.upm.es

One of these areas is the field of medicine, specifically the area of psychiatry. For this document the specific area in psychiatry is Obsessive-Compulsive Disorder. The use of computer science together with specific electronic devices and psychiatry has helped to develop different technologies that use databases [1], [5], [6], [7], video games (consoles, computers, cell phones with or without internet connection) [8], [9], [10], [11], web pages [1], [7], social network [12] and controlled environments to make diagnoses, procure several reactions and perform treatments [13], [14]. These controlled environments may vary, be that they are environments controlled externally by specialists [13], [15] - [22], environments controlled externally by patients [9], [11], [15], [16], [18], [20] - [22], to even environments controlled by devices linked through internet [2]. This systematic review focuses in the information and communication technologies that were used or created to help with Obsessive-Compulsive Disorder through the years in psychiatry. Each of the selected documents provide concise information about the developed or used technologies to help with the mental disorder known as Obsessive-Compulsive Disorder (OCD). The outcomes and conclusions of several of the selected studies to help with this particular mental disorder make it quite clear that further investigations are needed [2], [8], [11] [13], [19]. Researches, studies and technologies developed or used were vast and varied. Each of the selected studies has shown different outcomes with their advantages and limitations. The present study provides insight into the following research questions:

1. Which methods were used to procure the necessary data for the studies?
2. What technologies were used or developed to help with OCD?
3. What outcomes were procured from the usage of the information and communication technologies with OCD?

II. METHODOLOGY

A. Studies Selection Process

To procure relevant studies the information research was done using five well-known online databases which are related to computer science and psychiatry (Scopus, ScienceDirect, Web of Science, ACM Digital Library e IEEEexplore). The search for information was performed using different query strings until only one was chosen. The final query string selected was "OCD" which is the acronym that stands for Obsessive-Compulsive Disorder.

Information and Communication Technologies in Obsessive-Compulsive Disorder

Filters were applied to show all articles related to the area of Computer Science. The last performed search was on the 24th of September, 2019 which produced a total outcome of 348 articles. In these articles the first thing that was done was to discard duplicates, then a thorough manual selection was performed in the non-duplicate studies by first reading each of the abstracts and introductions, and in some cases an even deeper reading of the study. The finality of this thorough reading was to meet the inclusion and exclusion criteria that can be seen on **Table I**. In the article selection process, the one in charge was the second author. After which, the selected articles were sent to the first author to be double-checked, whom then proceeded to add 4 more articles. Both authors reached the conclusion that the selected final documents were in concordance to the subject of study, reaching 100% rate of approval to use the articles. The selected documents reached a total number of 21 that corresponded to published articles since the year 1995 until the year 2018.

Table I: Inclusion and exclusion properties

Inclusion Properties	Exclusion Properties
1. Published from the year 1995 until the 24th of September, 2019. 2. Different kind of articles, be that they are conference papers, published documents, etc. 3. Contain relevant information about recent researches and possible future investigations. 4. Contain information regarding databases or that mentions the creation or usage of one. 5. Contain information regarding controlled environments or mentions the creation or usage of one. 6. Contain information regarding video games or mentions the creation or usage of one. 7. Articles that relate Computer Science and OCD as their main component.	1. Non-necessary duplicates. 2. Non-related documents with the subject of study. 3. Documents that have OCD included in their name but have no relation to computer science. 4. Documents that contain different kinds of psychiatric disorders but have no relation to computer science. 5. Documents that contain subjects related to computer science but have no relation to psychiatry nor OCD.

B. Analysis

The selected documents were rigorously analyzed in such a way that the authors divided the studies in groups and sub-groups, according to each of the research questions. At the moment of writing this systematic review, the division of information in groups and sub-groups helped to manage the constant flow of information from the studies. Problems that arose regarding information inconsistencies were solved by the authors through continuous discussions.

III. RESULTS

This section shows the outcomes of the research questions focusing in the inclusion properties of the study, likewise, it shows which diagnoses were performed and which conclusions were reached.

A. Outline of reviewed studies

Of the 21 selected studies, most of these, practically 90% of them, were studies published since the year 2000 until the year 2018. Only 10% of these studies were published since the year 1990 until the year 2000. To diversify the studies, the relation between each of them and their outcomes was taken into account.

The studies were divided in different parts. The first part was the one where databases (4 studies) were created or used for tests or researches, present or future, regarding OCD. The second part was the one where controlled environments were created or used; be it virtual environments (7 studies) or physical environments (3 studies) to carry out inspections of different reactions or behaviors. The third part was the one where web pages (2 studies) or social network (1 study) were created or used. The fourth part was the one where video games were created or used; be it virtual reality based (2 studies) or varied (1 study) to procure different outcomes. The fifth part was about empirical researches related to the subject of study: Computer science (information and communication technologies) and OCD (1 study).

B. Methods used to procure the necessary data for the studies

This section seeks to provide an answer to the first research question.

Data compilation in the selected studies was varied, since most of them had solid test subjects (16 out of 21 studies) while the remaining ones were research articles (1 out of 21 study) or articles that detailed the development of a new technology (4 out of 21studies) to help in this specific field of psychiatry.

- **Test Subjects**

The recruitment of test subjects for each study was done in different ways; be it notice boards, hospital or university hospital in-patients with or without any kind of psychological disorder, outpatients with or without any kind of psychological disorder, normal people of varying ages ranging from 5 to 80 years old, through social networks and specific web pages that help with OCD treatment [1] - [3], [5] – [22].

The logs procured from these studies denote that the minimum quantity of subjects from which data could be gathered from were 8 subjects [14] and the maximum registered quantity amounted to 574 test subjects, be it from inside or outside of the country [12] with possibilities of expansion of more than 1000 test subjects [8].

- **Performed Tests**

As it can be noted in most of the documents, to procure the necessary data and test subjects psychological tests (9 studies) were performed. In various of the documents the performed tests were psychological and technological (7 studies). Some of these studies were focused in technological tests (3 studies) that were visual, repetition, memory, learning based to procure data. In some cases, the performed tests were Psycho-technological ones (2 studies), meaning they were psychological tests using psychiatry based technologies. An overview of these details can be seen on **table II**.

- **General Purpose**

This literary review notes the general aspects that appear with the different performed tests:

° Integration of computer science (technologies) in the field of psychiatry to help with the study of OCD through the years (4 studies).
° The usage of psychiatry based technology to help with diagnoses, follow-ups and treatments of OCD (7 studies).
° The generation of different kinds of technological strategies to help with OCD treatment (10 studies).

- **Test Features**

The tests performed to procure the necessary test subjects were generally of psychological type (90%), a few of these performed tests were purely technological (10%). All these tests, the technological and psychological ones, were based on psychiatry.

Table II: Simple overview about the features of performed tests and the number of participants.

Author / Study	Type of document	Type of test performed	Simple description	Testing staff	Number of participants
Modai, I., Saban, N.I., Stoler, M., Valevski, A., Saban, N., 1995	Article	Psychological	1) DSM-III-R (1987). 2) GAF (1987). 3) Schizoaffective diagnosis	1) Two experienced psychiatrist. 2) Psychologist with 7 years of clinical experience. 3) Experimented psychiatrists (Psychologist, psychiatrist social networkers)	41 out of 289 psychiatric in-patients diagnosed with OCD.
Hazarika, Neep, Chen, Jean Zhu, Tsoi, Ah Chung, Sergejew, Alex., 1997	Conference article	Psychological	1) DSM-III-R. 2) EEG.	1) Qualified neurologists and psychiatrists.	41 normal person's EEG, 60 schizophrenic persons EEG and 35 OCD persons EGG.
Vasios, C.E., Matsopoulos, G.K., Nikita, K.S., Uzunoglu, N., Papageorgiou, Ch., 2002	Conference article	Psychological	1) DSM-IV.	1) Two Psychiatrists.	23 patients with OCD, 14 first level schizophrenic patients, 24 depressive patients and 18 constant drug users.
Lack, C.W., Storch, E.A., 2007	Article	Psychological	Different and varied tests because it is an empirical review.	1) Varied amount of psychiatrists and specialists depicted through the document.	Non-specific amount of patients descripted.
Kim, K., Kim, C.-H., Cha, K.R., Park, J., Han, K., Kim, Y.K., Kim, J.-J., Kim, I.Y., Kim, S.I., 2008	Article	Psychological	1) DSM-IV.	1) Certified Psychiatrist who used MINI international Neuropsychiatry interview	33 OCD diagnosed subjects and 30 healthy control subjects.
Kim, K., Kim, S.I., Cha, K.R., Park, J., Rosenthal, M.Z., Kim, J.-J., Han, K., Kim, I.Y., Kim, C.-H., 2010	Article	Psychological	1) DSM-IV. 2) Y-BOCS	1) Licensed psychiatrist who used MINI international Neuropsychiatry interview	30 OCD diagnosed patients and 27 healthy control subjects.

Information and Communication Technologies in Obsessive-Compulsive Disorder

Authors	Type	Area	Instruments/Methods	Specialists	Participants
La Paglia, F., La Cascia, C., Rizzo, R., Riva, G., La Barbera, D., 2012	Article	Psychological	1) DSM IV-TR. 2) FAB. 3) Mann-Whitney test .	1) Non-specified amount of psychiatrists inside the laboratory of the university hospital of the University of Palermo.	10 OCD outpatients and 10 regular healthy control patients.
Sivalingam, R., Cherian, A., Fasching, J., Walczak, N., Bird, N., Morellas, V., Murphy, B., Cullen, K., Lim, K., Sapiro, G.,Papanikolopoulos, N., 2012	Conference article	Technological	Kinect video recordings were taken into account.	1) Non-specified amount of specialists through the day using the specified equipment (Kinect).	Different kids through the day inside the laboratory of Shirley G. Moore School.
McIngvale, E., Bakos-Block, C., Hart, J., Bordnick, P.S., 2012	Article	Psychological Technological	1) OCD Challenge Module.	1) Non-specified amount of specialists through the design, programming and testing of the making of the self-help program (Web site).	200 different users from 5 different countries.
Suraki, M.Y., Suraki, M.Y., 2013	Conference article	Technological	Different kind of technologies linked through internet.	1) Non-specified amount of specialists. (psychiatrist and engineers).	Innovative proposal for the treatment of OCD diagnosed persons within their homes.
La Paglia, F., La Cascia, C., Rizzo, R., Cangialosi, F., Sanna, M., Riva, G., La Barbera, D., 2014	Article	Psychological Technological	1) Validated Neuropsychological battery (FAB, TMT (A; B; A-B), TOL). 2) V-MET. 3) ANOVA.	1) Specialized psychiatrists (amount non-specified) from the same psychiatric department. 2) A computer and programming specialist from the IT area.	60 participants from which, 30 are OCD diagnosed patients and 30 are healthy control subjects.
La Paglia, F., La Cascia, C., Cipresso, P., Rizzo, R., Francomano, A., Riva, G., La Barbera, D., 2014	Conference article	Psychological Technological	1) Neuropsychological evaluation (TMT (A; B; A-B), TOL.). 2) V-MET.	1) Specialized psychiatrists (amount non-specified) from the same psychiatric department. 2) A computer and programming specialist from the IT area.	30 participants divided in 10 healthy control subjects, 10 OCD confirmed subjects and 10 schizophrenia confirmed subjects.
Pavelko, R.L., Myrick, J.G., 2015	Article	Psycho-Technological	1) QQO (Online Qualtrics Questionnaire).	1) Social media specialists (amount non-specified) from the University of Indiana.	574 recruited persons by the Mechanical Turk platform from Amazon.

McIngvale, E., Bordnick, P.S.f, Hart, J., 2015	Article	Psycho-Technological	Takes into account that it's a multi-access self-help web page and a review.	1) Psychiatrists and mental knowledge specialists (amount non-specified) from the Houston Texas University.	436 participants from different countries.
Fasching, J., Walczak, N., Bernstein, G.A., Hadjiyanni, T., Cullen, K., Morellas, V., Papanikolopoulos, N., 2016	Conference article	Psychological	1) CY-BOCS. 2) COIS-R. 3) BASC-2. 4) MASC-2.	1) Group of specialist (amount non-specified). researchers from different departments in the Minnesota University.	18 OCD diagnosed teens and 21 healthy control subjects.
Schepers, N., Derard, P., Acca, C., Fontaine, P., 2016	Conference article	Technological	1) V-RET.	1) Specialist doctors (amount non-specified) from Vincent Van Gogh hospital in Belgium..	Non-specified amount of participants because it is still a study in progress.
Laforest, M., Bouchard, S., Crétu, A.-M., Mesly, O., 2016	Article	Psychological	1) DSM-IV-TR. 2) DSM-5. 3) Y-BOCS. 4) S-TAI, SAS. 5) CTI. 6) CPG. 7) CES.	1) Licensed psychologist supervising therapists 2) Three research assistants with experience in the use of VR.	32 participants from which 12 are OCD diagnosed patients and 20 don't have any severe mental trauma.
Van Bennekom, M.J., Kasanmoentalib, M.S., De Koning, P.P., Denys, D., 2017	Article	Psychological Technological	1) Y-BOCS. 2) MINI. 3) Mann Whitney test. 4) DSM-IV. 5) IARE.	1) Specialists (amount non-specified) from the Psychiatric department in Amsterdam and from the Neuroscience institute in the Netherlands.	16 participants from which 8 are OCD diagnosed patients and 8 are healthy control subjects.
Pearcy, B.T.D., McEvoy, P.M., Roberts, L.D., 2017	Article	Psychological Technological	1) IGD-20T. 2) Likert Scale. 3) Test/re-test reliability. 4) Convergence validation. 5) Game addiction scale. 6) K10. 7) WHODAS.	1) Specialists (amount non-specified) from the school of psychology from the University of Curtin in Australia.	404 participants from which 285 persons belong to the old people community and 119 are university students.

Hong, J.S., Kim, S.M., Aboujaoude, E., Han, D.H., 2018	Article	Psychological Technological	1) Y-BOCS. 2) DSM-IV. 3) CBT. 4) BDI 5) ERP. 6) BAI	1) Specialized psychiatrists (amount non-specified) from the department of psychology in the university hospital of South Korea and Stanford Medicine University.	35 participants from which 20 are OCD diagnosed patients and 15 are healthy control subjects.
Cameron, C., Khalil, I., Castle, D., 2018	Article	Psychological Technological	Different performed tests, because it is the research of a program for precise deduction of mental illnesses like OCD and ASD.	1) Specialists from the department of psychiatry and RMIT department in the University of Melbourne Australia.	8 Participants. Each of these participants doing 5 video data simulations.

C. Brief review about the usage of computer technology regarding OCD

This section helps to clear doubts regarding the second research question.

Reference [15] shows the first register of the usage of computers or any kind of technology for the detection (diagnosis) of Obsessive-Compulsive disorder. This register occurs in the early 90's, the used system was the one developed by Kraepelin. It is noted that this developed technology wasn't used again in future researches or tests because it wasn't very user-friendly.

It is noted that the first eight logs regarding the usage of technologies to treat Obsessive-Compulsive Disorder were registered since the year 2006, with the first publications appearing in the year 1987 and 1988.

- **Evolution of computer technologies and their meaning for OCD**

From the early 80's (1983) through the late 90's (1999) decade it's recognized that computer science starts to have an accelerated evolution on a wide scale. Portable computers are created, software (development) and systems that computers handle are improved.

Thanks to these developments in the year 1988 the first treatment method for OCD called OC-Check is created, nevertheless, it isn't well received as a treatment method because it works more as a control (follow-up) application.

In the year 1992 two different studies from psychiatric specialists are published, that help the psychiatry based technologies evolve regarding diagnoses (**Computerized Y-BOCS**) and treatment (**BT STEPS**) for OCD [15].

- **Created or Used Technologies**

The different used or created technologies are shown for each of these studies with a very basic overview, for better details they can be seen on **table III**.

According to records, it is recognized that the first successful diagnosis and treatment methods for OCD are published in the year 1992. Thanks to these, new publications which use new emerging psychiatry based technologies to expand and improve diagnoses and treatments start appearing. One of the most used and recognized technologies in these studies is the virtual reality (VR).

Reference [16] shows how the usage of virtual reality is recognized as a tool to induce anxiety states in OCD diagnosed patients, thus, it is confirmed that the virtual environment is feasible as a method to provoke reactions. Recognizing that VR is not a real life experience that could validate if the experiences that happened in this environment could be the same as a real one, then the usage of this environment is more inclined as an ERP (**Event-related Potential**) tool.

Table III: General Information about the used or created technologies for each article.

Author / Study	Used / Created Technologies	Features	Basic description	Type of environment
Modai, I., Saban, N.I., Stoler, M., Valevski, A., Saban, N., 1995	1) Neural Network (NN).	Image based	Exploration and Information recompilation.	Physical environment controlled by Specialists.

Hazarika, Neep, Chen, Jean Zhu, Tsoi, Ah Chung, Sergejew, Alex., 1997	1) Artificial Neural Network (ANN). 2) Wavelet transform (EEG classification).	Image based	Exploration and Information gathering.	Physical environment controlled by Specialists.
Vasios, C.E., Matsopoulos, G.K., Nikita, K.S., Uzunoglu, N., Papageorgiou, Ch., 2002	1.- MVAR (Multivariate autoregressive model) 2.- AR (Autoregressive model). 3) Neural Network (NN) 4) ERP (Event-related potentials).	Event Based	Location and Memorization.	Physical environment controlled externally by participants (subjects, specialists).
Lack, C.W., Storch, E.A., 2007	1) CSA (Completely self-administrable). 2) AT (Attached treatment) 3) HH (Handheld computers). 4) PC (Personal desktop computers). 5) TEL (Software packages sent through telephone ways).	Based on different features.	Exploration. Location. Different kinds, non-specific.	Different kinds of environments, be they controlled externally or internally or non-controlled environments.
Kim, K., Kim, C.-H., Cha, K.R., Park, J., Han, K., Kim, Y.K., Kim, J.-J., Kim, I.Y., Kim, S.I., 2008	1) Hardware: Computer compatible with IBM and a head mounted SVGA with color screen, with a 3-degree freedom tracker. 2.) Software: Virtual reality environment oriented to the average Korean household for impulse monitoring	Image based	Repetition and achievement based simulator.	Virtual environment controlled externally by participants (subjects, specialists).
Kim, K., Kim, S.I., Cha, K.R., Park, J., Rosenthal, M.Z., Kim, J.-J., Han, K., Kim, I.Y., Kim, C.-H., 2010	1) Hardware: Computer compatible with IBM and a head mounted SVGA with color screen, with a 3-degree freedom tracker. 2) Standard Joystick, tracker for environment navigation. 3) Software: A virtual house and office designed using 3D-MAX and rendered for the A6 GameStudio to provoke checking behaviors.	Image based	Event and repetition based simulator to make diagnoses.	Virtual environment controlled externally by participants (subjects, specialists).
La Paglia, F., La Cascia, C., Rizzo, R., Riva, G., La Barbera, D., 2012	1) V MET (virtual multiple errand test). 2) VR (virtual reality).	Image based	Events, repetition and test based simulator.	Virtual environment controlled externally by participants (subjects, specialists).
Sivalingam, R., Cherian, A., Fasching, J., Walczak, N., Bird, N., Morellas, V., Murphy, B., Cullen, K., Lim, K., Sapiro, G.,Papanikolopoulos, N., 2012	1) Kinect. 2) Multi Kinect calibration.	Image based	Exploration and Location based on Kinect technology.	Physical environment controlled externally by specialists.
McIngvale, E., Bakos-Block, C., Hart, J., Bordnick, P.S., 2012	1) OCDCHALLENGE. (Web Page)	Internet based.	Diagnosis: Self-help web page based on computer science and psychiatry.	Internet environment (web page) developed using databases for external control by participants (subjects, specialists).
Suraki, M.Y., Suraki, M.Y., 2013	1) IOT (Internet of things). 2) RFID (Radio Frequency Identification).	Internet based. Location based.	Exploration and Location based on Internet connected devices.	Physical environment controlled externally by participants (subjects, specialists).

La Paglia, F., La Cascia, C., Rizzo, R., Cangialosi, F., Sanna, M., Riva, G., La Barbera, D., 2014	1) V MET (virtual multiple errand test) 3) VR (virtual reality)	Image based	Events, repetition and tests based simulator.	Virtual environment controlled externally by participants (subjects, specialists).
La Paglia, F., La Cascia, C., Cipresso, P., Rizzo, R., Francomano, A., Riva, G., La Barbera, D., 2014	1) NeuroVR 2.0. 2) V MET (virtual multiple Errand test) 3) VR (virtual reality)	Image based	Events and repetition based simulator.	Virtual environment controlled externally by participants (subjects, specialists).
Pavelko, R.L., Myrick, J.G., 2015	1) Internet (Web Pages). 2) Social Media (Twitter). 3) Adobe Photoshop 4) InDesign	Internet based.	Exploration and data recompilation through social media.	Social environment developed using databases and based on internet.
McIngvale, E., Bordnick, P.S.f, Hart, J., 2015	1) OCDChallenge website (ocdchallenge.com)	Internet based.	Diagnosis: Self-help web page based on computer science and psychiatry.	Internet environment (web page) developed using databases for external control by participants (subjects, specialists).
Fasching, J., Walczak, N., Bernstein, G.A., Hadjiyanni, T., Cullen, K., Morellas, V., Papanikolopoulos, N., 2016	1) COACH (Cognitive Orthosis for Assisting Activities in the home).	Image based.	Exploration and location based on repetitive events.	Virtual environment (videos) controlled externally by participants (subjects, specialists).
Schepers, N., Derard, P., Acca, C., Fontaine, P., 2016	1) VR (Virtual Reality). 2) Smartphone. 3) VRET (Virtual Reality Exposure Therapy) 4) Virtual reality Homido headphones for Smartphones. 5.- Cardboard Camera. 6.-Cardboard VR 3D Laby.	Image based.	Virtual exposition based simulator.	Virtual environment controlled externally by participants (subjects, specialists).
Laforest, M., Bouchard, S., Crétu, A.-M., Mesly, O., 2016	1)VR (Virtual reality). 2) Psyche (6 sided wireless immersion camera). 3) Viztek projector. 4) 6 computer cluster. 5) Virtool VpPublisher. 6) Windows XP 32 bits S2. 7) OpenGL 2.0. 8) Wireless Motion Sensor IS-900 VET Intersense. 9) CISCO system cluster Switch catalyst 2950 100MBITs/s 10) Sound card SoundBlaster X-Fi.	Image based	Simulator	Virtual environment controlled externally by participants (subjects, specialists).
Van Bennekom, M.J., Kasanmoentalib, M.S., De Koning, P.P., Denys, D., 2017	1)VR (virtual reality). 2) Pentium 4 computer and Intel graphics driver. 3) Lenovo G505s Laptop. 4) Mouse. 5) Stereo Headphones.	Image based	Event based simulation game.	Virtual environment controlled externally by participants (subjects, specialists).
Pearcy, B.T.D., McEvoy, P.M., Roberts, L.D., 2017	1) IGD (internet gaming disorder). 2) Qualtrics.com (Web Page).	Image based	Internet Games.	Non-specific environment.
Hong, J.S., Kim, S.M., Aboujaoude, E., Han, D.H., 2018	1) Video Games (Different games through a limited time). 2) Cell phone games (RAW HAND – Android phone).	Image based	Simulation game using cell phones.	Physical environment controlled externally by participants (subjects, specialists).

| Cameron, C., Khalil, I., Castle, D., 2018 | 1) SURF (Speed-up Robust Features).
2) TMHM (Temporal Motion Heat Maps).
3.- VW (visual words) and SVM based classification.
4.- SURF based MATLAB. | Movement based. Word recognition | Exploration and events repetition. | Physical environment controlled externally by participants (subjects, specialists). |

A. Types of Outcomes

This sections gives light to doubts generated regarding the third research question. The studies selection process for this systematic review as is known was rigorously performed using the inclusion and exclusion properties. Nevertheless, one more of the major points that was taken into account at the selection process was the different types of outcomes each of these studies showed. We not only wanted to show successful outcomes, but, we wanted to show that some studies still need future researches even if they showed favorable outcomes. In most of these studies the outcomes were so positive that the persons that participated in these studies were able to be reintegrated to society as active members again. Other studies couldn't be concluded because of the need for further researches.

Reference [8] outcomes show that the data procured through the research couldn't be fully conclusive because it is still a research in progress.

Reference [11] outcomes show that the usage for serious games can help improve symptoms in OCD diagnosed persons. For a better detail of more outcomes of these studies please refer to **table IV**.

Table IV: Brief description of the outcomes of each article.

Author / Study	Brief description of outcomes	Consistency (Observation)
Modai, I., Saban, N.I., Stoler, M., Valevski, A., Saban, N., 1995	The neural network had a successful convergence of 97% after the 8-week outcome for the subjects. Because it is a delicate system, it's parameters are delicate too, thus, a positive outcome is reached if positive changes are done. Nevertheless, these positive changes can only be seen in persons that use antidepressants, have schizopositive symptoms, etc. The group that was integrated by OCD and resistant depression persons showed that even if positive changes were made to their values, their final outcome was negative.	For information compilation and diagnosis of persons with different psychiatric problems, this technology is recommended. Because this technology can predict outcomes (good or bad) using random values.
Hazarika, Neep, Chen, Jean Zhu, Tsoi, Ah Chung, Sergejew, Alex., 1997	The classification is possible using ANN because the coefficients shown for the cases of schizophrenia had a classification outcome of 71%, while normal patients had an outcome of 66% and the less satisfactory outcome belonged to the OCD EEG images because of their random signals.	The classification is possible for different psychiatric cases and normal patients, but, for OCD diagnosed patients their classification isn't well received
Vasios, C.E., Matsopoulos, G.K., Nikita, K.S., Uzunoglu, N., Papageorgiou, Ch., 2002	A proposition to classify ERPs' is made. This combines the MVAR with the optimization SA technique. This allows the gathering of optimal characteristics from different categories. The most optimal logs regarding classification of OCD ERPs' against normal patients ERPs' was of 91%.	The classification of different ERP logs is consistent and efficient. It's demonstrated that the OCD logs were the most optimal.
Lack, C.W., Storch, E.A., 2007	Acknowledging that a 2.5% of United States population suffers from OCD the development of new and different technologies to help with its treatment are highlighted in this type of review.	Presents the beginnings of the usage of computer technologies to diagnose and treat OCD.
Kim, K., Kim, C.-H., Cha, K.R., Park, J., Han, K., Kim, Y.K., Kim, J.-J., Kim, I.Y., Kim, S.I., 2008	Outcomes of this study prove that the usage of virtual reality in persons diagnosed with OCD provoke anxiety. Virtual reality is used as a diagnosis tool than a treatment tool. Anxiety correlation is confirmed according to patient symptoms, be that they have an illness or not. Nevertheless, outcomes show that the usage of virtual reality together with ERP provoke a great anxiety reduction after exposure in OCD diagnosed persons. Study limitations could be solved because virtual reality has a great correlation with validated BAI (Beck Anxiety Inventory).	It's demonstrated that exposing OCD diagnosed patients to controlled virtual reality environments helps to reduce anxiety levels, even though, the principal focus of this study was the measurement of anxiety provoked by virtual environments.
Kim, K., Kim, S.I., Cha, K.R., Park, J., Rosenthal, M.Z., Kim, J.-J., Han, K., Kim, I.Y., Kim, C.-H., 2010	Outcomes demonstrate that normal persons and OCD diagnosed persons don't differ much when doing the same kind of tests, having practically the same age, sex, IQ. The outcomes for OCD participants was of 73.23%, meanwhile, the outcomes for healthy controls was of 69.80%. Other test outcomes too demonstrate that OCD patient get better parameters than healthy controls and the behavior checking scale in an environment is verified. This study is recognized as the first one to use VR technology for behavior checking.	First study focused on checking behavior in OCD diagnosed persons. It demonstrates that these persons are prone to have a continuous compulsive checking behavior.

Information and Communication Technologies in Obsessive-Compulsive Disorder

La Paglia, F., La Cascia, C., Rizzo, R., Riva, G., La Barbera, D., 2012	Mann-Whitney test is used for the assessment of performances of usage of V-MET in healthy control subjects and OCD diagnosed subjects. It's demonstrated that patients take time on planning strategies than healthy patients. It is thought that OCD patients have tendencies to observe and work more assiduous than healthy patients.	Outcomes show the usage of V-MET as an executive function diagnostic tool. OCD patients are prone to take more time in finishing errands than healthy subjects.
Sivalingam, R., Cherian, A., Fasching, J., Walczak, N., Bird, N., Morellas, V., Murphy, B., Cullen, K., Lim, K., Sapiro, G.,Papanikolopoulos, N., 2012	Proposition to create a child (5 years old) tracking system that uses a multi sensor application based on multiple Kinect. It is used check the behavior changes in kids. It gathers information using the virtual model (X, Y, Z) and movement sensors, but this has a problem which is the stationary objects. Another problem is that the system is not an automatic one, meaning, that if the same subject uses different clothes on different days then the subject can't be recognized.	Proposes the creation of a tracking system that has some problems, which can be solved in future researches.
McIngvale, E., Bakos-Block, C., Hart, J., Bordnick, P.S., 2012	Web page OCDchallenge.com is created, this document shows how the development, programming and testing process was performed regarding this particular web page. 3 interactive modules are created which are: Assessment, awareness acquisition and Intervention. The web page follows the psychiatric standards and was evaluated by professional psychiatrists. It is a self-help web page for treatment and to avoid relapses.	It's an accessible self-help 'application' for all type social classes. It shows different outcomes and still needed further research.
Suraki, M.Y., Suraki, M.Y., 2013	Proposes the usage of IOT to help in the treatment of OCD diagnosed patients. It explains how the different electronic devices through the house are located and connected using internet. This allows the therapist outside of range if a patient has used the same object too many times.	Innovative proposition that uses internet linked devices and an online database with the help of a therapist. Needs further researches.
La Paglia, F., La Cascia, C., Rizzo, R., Cangialosi, F., Sanna, M., Riva, G., La Barbera, D., 2014	Neuropsychological tests show that cognitive levels stay intact for healthy and OCD diagnosed subjects. Clinical samples show that these levels are significantly low compared to memory tests. The use of ANOVA after virtual tests show that OCD patients have significant difficulties when doing tasks, specially task that had attention functions. The ecological validation of V-MET as a diagnosis tool for executive functions in OCD patients is proven true.	Typical problems that OCD patients go through are shown in this study. It too shows the problems these patients have when they do plans and the impaired behavior they suffer.
La Paglia, F., La Cascia, C., Cipresso, P., Rizzo, R., Francomano, A., Riva, G., La Barbera, D., 2014	When performing the tests, the genders, ages and levels of educations of the of the 3 group of patients (healthy controls, OCD, Schizophrenia) were similar. Classical Neuropsychological tests were performed to measure cognitive functions and their outcomes demonstrate these aren't always accurate compared to healthy controls. According to MMSE OCD patient cognitive levels may vary. V-MET showed to be more susceptible to OCD and schizophrenic patients than healthy controls.	Traditional neuropsychological tests are reliable but their outcomes are better appreciated after the tests are done. Meanwhile, V-MET tests continuously show the different physical changes when the tests are being performed.
Pavelko, R.L., Myrick, J.G., 2015	3 types of studies were performed (frame content, avatar genre and OCD self-identification). To procure the necessary data, ANCOVA analysis was performed in which the male and female participants showed different values. It's demonstrated that self-proclaimed OCD users had better likeability grades never minding their frame content, meanwhile, non-self-proclaimed OCD users didn't have such good grades even if they used the 3 types of studies.	It demonstrates that self-proclaimed OCD users on social media don't have any negative nor positive effect on their regular lives and that other persons (healthy persons) have a better reception of them.
McIngvale, E., Bordnick, P.S.f, Hart, J., 2015	The data outcome for this study was procured by performing chi square tests in relation to Y-BOCS and frequencies on the 436 participants which 63.1% were women and 36,9% were men. Most of the participants admitted to have found about the web page while they were surfing through the internet or by a professional. 89% of participants using OCD challenge show improvements.	The use of ERPs by an online program in conjunction with evidence-based interventions are novel treatment techniques.
Fasching, J., Walczak, N., Bernstein, G.A., Hadjiyanni, T., Cullen, K., Morellas, V., Papanikolopoulos, N., 2016	Data compilation was performed by watching different videos. Each of these videos was a participant's recording. 6 of these videos weren't taken into consideration because of errors in the recordings. The activity taken into consideration was about the performance of hand-washing. It shows the quantity and consistency of the activity performed by a kid.	The efficiency to use videos to check if a kid shows OCD symptoms has an accuracy of 81% according to logs.
Schepers, N., Derard, P., Acca, C., Fontaine, P., 2016	The usage of smartphones to record physical exercises and other treatments are a great advantage in the treatment of OCD. These recordings can be send to therapists for verification and error correction. Better preparation between therapists and patients through online sessions and home tasks to do.	Because it is a study in progress the information that the study has is limited. It is known that future researches are going to be performed.

Laforest, M., Bouchard, S., Crétu, A.-M., Mesly, O., 2016	Covariance analysis are performed on repetition scales with 2 groups of participants (with and without OCD) for 2 environments (controlled and contaminated). These determine the effectiveness of virtual environments to induce anxiety responses in OCD diagnosed patients that have a specific contaminant. Square chi tests outcomes determined that there are no relevant different before and after performing the tests. ANOVA tests outcomes demonstrated that contaminated environments showed significant differences.	Demonstrates that virtual reality exposure produce anxiety and that these effects can happen in real environments too. This contributes in the creation of virtual environments to help with OCD anxiety measures.
Van Bennekom, M.J., Kasanmoentalib, M.S., De Koning, P.P., Denys, D., 2017	Patients had more significant outcomes regarding provoked emotions when using virtual reality, nevertheless, significant differences can't be easily detected. Anxiety provocation demonstrates that for each item different outcomes were generated. OCD diagnosed patients showed a higher degree of compulsions (3 times) than healthy patients. Most of the OCD patients didn't show any adverse effects after the tests only 1 patient showed some insecurities thanks to a contaminated laptop.	First virtual reality game based on videos to provoke and assess OCD symptoms. Adverse effects when using this kind of game were minimal. It's shown that for each patient their OCD varied by object.
Pearcy, B.T.D., McEvoy, P.M., Roberts, L.D., 2017	The study examines the IGDs' comorbidity conjoint to mental illness. Using square chi tests it is shown that participants are prone to suffer mental illnesses than those that aren't from the IGD group. T tests verified that IGD participants had greater values in mental disorders than those that didn't have IGD.	Different hypothesis are demonstrated which theorize that IGD greatly influences the acquisition of mental illnesses through different disorders, anxiety, etc.
Hong, J.S., Kim, S.M., Aboujaoude, E., Han, D.H., 2018	The study demonstrates that OCD diagnosed patients have a significant improvement after the serious game. When performing the tests there weren't significant differences regarding age or gender between patients with OCD and healthy control patients. Nevertheless, when performing the psychological tests there existed significant differences. After 3 weeks of continuous usage of the serious game the outcome values in the different tests showed improvement for the OCD patients. Brain connections too showed improvement after the three weeks.	These outcomes suggest that brain connections have a significant improvement after the use of the serious game and therefore, there is an improvement in people with OCD due to the different chemical results these tests generate.
Cameron, C., Khalil, I., Castle, D., 2018	The study proposes a system able to recognize and group-up simulated compulsive behaviors in clusters, besides being able to provide a relative anxiety metric. Data compilation was done after the verification of heat images, and integrate them in the technical computing MATLAB package. All the images were gathered from 40 different video recordings; these recordings were OCD simulations in different angles with different kinds of focus and lightings. An accuracy of 82% on average was procured from all instances (Quantity of tests = 5).	The benefits of using this system are high in such a way that it gives the specialists in mental illnesses a window to understand in a more detailed way the compulsions of their most particular patients.

IV. DISCUSSION

It is recognized that the outcomes of the used technologies in this study are varied and that each of these have their positive and negative points. Nevertheless, even with all the advances in technology the study of the mind and different mental disorders hasn't reached their maximum capacity. Next, we discuss in more detail 3 essential aspects.

A. Design of Applications

It is noted that for each study the technologies (applications, software, etc.) used were varied, in some cases new technologies were created and in other cases further researches were needed for the diagnosis and treatment of OCD. Nevertheless, something that all these technologies take into account is that they are all based on psychiatry or they have the need for a specialized psychiatrist for their creation or information gathering.

B. Usage of Virtual Reality

Virtual reality has had such a great reception in these types of studies, specially the studies referenced for this document. This technology main focus has been to prove the induction of different reactions (anxiety, repetition, fear, etc.) in OCD diagnosed patients. Most of the thesis that appear in the studies referenced in this document are proven true.

This technology has been such a great help because it allows the patients to interact with their environment from a safe place. It also allows the specialists to witness the different behaviors the patients may have during this interaction.

C. Possible Technology

It is recognized that as time passes the development of new and advanced technologies is a given fact. Taking into consideration that OCD patients continue to appear constantly in the society no matter the year, age or time. One major and possible technological recommendation for future researches is the usage of holograms together with Virtual reality and possibly EDM (Electronic Dance Music) to diagnose or treat OCD.

Searching through databases, studies that use these 3 types of technologies together with psychiatry couldn't be found.

First, researches regarding holograms and EDM together with psychiatry should be conducted more thoroughly. There already exist studies that use virtual reality and OCD together and some limited studies regarding Virtual reality and holograms that don't include OCD (Diagnosis, Treatment).

Searching solid data about the use of EDM by person, it was found that most persons liked to use environmental and relaxing sounds for self-help with OCD. It is proved that relaxing and environmental sounds do help for a limited time, but aren't a solid treatment. However, the use of EDM for OCD treatment hasn't had thorough long time researches.

V. CONCLUSION

This study presents how the use of computer technologies (Hardware and software) to help diagnose and treat OCD have evolved through the years. The outcomes of these studies are varied and some require further researches. It is noted that this study is not focused on biomedicine but the different computer technologies used to help with this particular mental disorder. One of the purposes of this study is to maybe be used as a starting guide for future researches.

- **Study Limitations**

This review is limited because it only uses the information found in five different databases until the year 2018. Year 2019 and onwards researches weren't taken into account for this study, which means it is a very big limitation for this study. Even, if the number of documents used for this systematic review is limited. Each of these studies were rigorously selected to avoid future drawbacks.

REFERENCES

1. McIngvale, E., Bordnick, P.S.f, Hart, J., "A Self-help Website for Obsessive Compulsive Disorder: Who is Accessing the Website," Journal of Technology in Human Services, Volume 33, Pages 191-203, May 2015. Copyright © Elsevier Science Ltd. All rights reserved.
2. Suraki, M.Y., Suraki, M.Y., "Technology Therapy for Obsessive-Compulsive Disorder Based on Internet of Things," 7th International Conference on Application of Information and Communication Technologies, AICT 2013; Baku; Azerbaijan; 23 October 2013 through 25 October 2013.
3. Fasching, J., Walczak, N., Bernstein, G.A., Hadjiyanni, T., Cullen, K., Morellas, V., Papanikolopoulos, N., "Automated Coding of Activity Videos from an OCD Study," 2016 IEEE International Conference on Robotics and Automation, ICRA 2016; Stockholm Waterfront Congress Center Stockholm; Sweden; 16 May 2016 through 21 May 2016.
4. Denning, P., "Crossing the Chasm: The Keys to a Coherent Profession Are Bridges between Computing Technologists and the Multitude," Vol 44, No. 4, 21-25, April 2001.
5. Modai, I., Saban, N.I., Stoler, M., Valevski, A., Saban, N., "Sensitivity profile of 41 psychiatric parameters determined by neural network in relation to 8-week outcome," Computers in Human Behavior, Volume 11, Issue 2, Pages 181-190, Summer 1995. Copyright © Elsevier Science Ltd.
6. Hazarika, Neep, Chen, Jean Zhu, Tsoi, Ah Chung, Sergejew, Alex., "Classification of EEG signals using the wavelet transform," Signal Processing Volume 59, Issue 1, Pages 61-72, May 1997. Copyright © Elsevier Science Ltd.
7. McIngvale, E., Bakos-Block, C., Hart, J., Bordnick, P.S., "Technology and Obsessive Compulsive Disorder an Interactive Self-Help Website for OCD," Journal of Technology in Human Services, Volume 30, Pages 128-136, July 2012. Copyright © Elsevier Science Ltd.
8. Schepers, N., Derard, P., Acca, C., Fontaine, P., "Using Smartphones Apps in Psychotherapy Experiences with PTSD, OCD and Panic Disorder Patients," 2016 Virtual Reality International Conference, VRIC 2016; Laval; France; 23 March 2016 through 25 March 2016.
9. Van Bennekom, M.J., Kasanmoentalib, M.S., De Koning, P.P., Denys, D., "A Virtual Reality Game to Assess Obsessive-Compulsive Disorder," CyberPsychology, Behavior, and Social Networking Volume 20, Issue 11, Pages 718-722, November 2017. Copyright © Mary Ann Liebert, Inc.
10. Pearcy, B.T.D., McEvoy, P.M., Roberts, L.D., "Internet Gaming Disorder Explains Unique Variance in Psychological Distress and Disability After Controlling for Comorbid Depression, OCD, ADHD, and Anxiety," CyberPsychology, Behavior, and Social Networking Volume 20, Issue 2, Pages 126-132, 1 February 2017. Copyright © Mary Ann Liebert, Inc.
11. Hong, J.S., Kim, S.M., Aboujaoude, E., Han, D.H., "Investigation of a Mobile ''Serious Game'' in the Treatment of Obsessive–Compulsive Disorder a Pilot Study," Games for Health Journal Volume 7, Issue 5, Pages 317-326, October 2018. Copyright © Mary Ann Liebert, Inc.
12. Pavelko, R.L., Myrick, J.G., "That's so OCD The effects of disease trivialization via social media on user perceptions and impression formation," Computers in Human Behavior, Volume 49, Pages 251-258, August 2015. Copyright © Elsevier Science Ltd. All rights reserved.
13. Vasios, C.E., Matsopoulos, G.K., Nikita, K.S., Uzunoglu, N., Papageorgiou, Ch., "A Decision Support System for the Classification of Event-Related Potentials," 6th Seminar on Neural Network Applications in Electrical Engineering, NEUREL 2002; Faculty of Electrical Engineering, University of Belgrade, Yugoslavia; Serbia; 26 September 2002 through 28 September 2002.
14. Cameron, C., Khalil, I., Castle, D., "Determining Anxiety in Obsessive Compulsive Disorder through Behavioural Clustering and Variations in Repetition Intensity," Computer Methods and Programs in Biomedicine, Volume 160, Pages 65-74, July 2018. Copyright © Elsevier Science Ltd.
15. Lack, C.W., Storch, E.A., "The use of computers in the assessment and treatment of obsessive–compulsive disorder," Computers in Human Behavior Volume 24, Issue 3, Pages 917-929, May 2008. Copyright © Elsevier Science Ltd.
16. Kim, K., Kim, C.-H., Cha, K.R., Park, J., Han, K., Kim, Y.K., Kim, J.-J., Kim, I.Y., Kim, S.I., "Anxiety Provocation and Measurement Using Virtual Reality in Patients with Obsessive-Compulsive Disorder," CyberPsychology & Behavior, Volume 11, Number 6, Pages 637-641, 2008. Copyright © Mary Ann Liebert, Inc.
17. Kim, K., Kim, S.I., Cha, K.R., Park, J., Rosenthal, M.Z., Kim, J.-J., Han, K., Kim, I.Y., Kim, C.-H., "Development of a computer-based behavioral assessment of checking behavior in obsessive-compulsive disorder," Comprehensive Psychiatry Volume 51, Issue 1, Pages 86-93, January–February 2010. Copyright © Elsevier Science Ltd.
18. La Paglia, F., La Cascia, C., Rizzo, R., Riva, G., La Barbera, D., "Assessment of executive functions in patients with obsessive compulsive disorder by Neuro Virtual Reality," Studies in health technology and informatics Volume 181, Pages 98-102, September 2012. Copyright © Elsevier Science Ltd.
19. Sivalingam, R., Cherian, A., Fasching, J., Walczak, N., Bird, N., Morellas, V., Murphy, B., Cullen, K., Lim, K., Sapiro, G., Papanikolopoulos, N., "A Multi-Sensor Visual Tracking System for Behavior Monitoring of At-Risk Children," 2012 IEEE International Conference on Robotics and Automation, ICRA 2012; Saint Paul, MN; United States; 14 May 2012 through 18 May 2012.
20. La Paglia, F., La Cascia, C., Rizzo, R., Cangialosi, F., Sanna, M., Riva, G., La Barbera, D., "Cognitive Assessment of OCD Patients NeuroVR vs Neuropsychological Test," Annual Review of Cybertherapy and Telemedicine 2014, Volume 199 of Studies in Health Technology and Informatics, Pages 40-44, May 2014. Copyright © Elsevier Science Ltd.
21. La Paglia, F., La Cascia, C., Cipresso, P., Rizzo, R., Francomano, A., Riva, G., La Barbera, D., "Psychometric Assessment Using Classic Neuropsychological and Virtual Reality Based Test a Study in Obsessive-Compulsive Disorder (OCD) and Schizophrenic Patients," Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering Volume 100, Pages 23-32, May 2014.
22. Laforest, M., Bouchard, S., Crétu, A.-M., Mesly, O., "Inducing an Anxiety Response using a contaminated Virtual Environment Validation of a Therapeutic tool for Obsessive-Compulsive Disorder," Virtual and Augmented Reality for Education and Training, Frontiers in ICT, Volume 3, Article number 18, Issue SEPTEMBER 2016. Copyright © Elsevier Science Ltd.
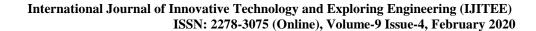
AUTHORS PROFILE

Ricardo Naranjo is currently a Professor at the Department of Computer Science and Engineering at Universidad Politécnica Salesiana. He has over 17 years of experience teaching at the undergraduate level and 7 years of Software Development Industry experience. He holds a Master's Degree in Software and Systems of the Universidad Politécnica de Madrid. He is pursuing his Ph.D. in Software, Systems and Computing of the Universidad Politécnica de Madrid. He has authored various book chapters. His areas of Research are ICT accessibility for persons with disabilities, Software Usability and User Experience, Educational Informatics, Augmented Reality. He has written several research articles in his areas of research.

Ricardo Valverde, is a research scholar at the Department of Computer Science and Engineering at Universidad Politécnica Salesiana. He has over 2 years of Software Development Industry experience. His area of Research is Information and Communications Technology.

Loïc Martínez Normand, is Adjunct Professor of Computer Science at Universidad Politécnica de Madrid, where he teaches courses on software development, human-computer interaction and ICT accessibility. He is Associate Dean for Academic Affairs. He has over 23 years of experience teaching at the undergraduate and postgraduate level. His main research interest is ICT accessibility for persons with disabilities. He actively participates in national and international standardization activities defining accessibility requirements for ICT products and services, such as EN 301 549, the European Standard for the public procurement of accessible ICT. He has written several research articles in his areas of research.

Retrieval Number: D1927029420 /2020©BEIESP
DOI: 10.35940/ijitee.D1927.029420
Journal Website: www.ijitee.org

2358

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication