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Interaction between neuroscience and happiness: assessment from Artificial Intelligence advances

Rolando Eslava-Zapata[1,*], Verenice Sánchez-Castillo[2] and Edixon Chacón-Guerrero[3]

[1]Universidad Libre Colombia, Cúcuta, Colombia.
[2]Universidad de la Amazonía, Florencia, Colombia.
[3]Universidad de Los Andes, San Cristóbal, Venezuela.

Abstract

INTRODUCTION: In recent years, there has been a convergence between Artificial Intelligence and neuroscience, particularly in studying the brain and developing treatments for neurological disorders. Artificial neural networks and deep learning provide valuable insights into neural processing and brain functioning. Recent research tries to explain how neural processes influence an individual's happiness.
OBJECTIVES: To evaluate the interaction between neuroscience and happiness based on the advances in Artificial Intelligence.
METHODS: A bibliometric analysis was performed with articles from the Scopus database in 2013-2023; likewise, the VOSviewer was used for information processing.
RESULTS A total of 603 articles were obtained, and it is evident that the most significant scientific production is centered in the United States (184), United Kingdom (74), and China (73). Three clusters are generated from the Co-occurrence - Author Keywords analysis. The first cluster, red, is related to Artificial Intelligence applications for predicting happiness; the second cluster, green, is associated with Artificial Intelligence tools in neuroscience; and the third cluster, blue, is related to neuroscience in psychology.
CONCLUSION: Neuroscience research has made significant leaps in understanding mental processes such as emotions and consciousness. Neuroscience has encountered happiness and is opening up to an approach that seeks evidence to understand people's well-being supported by Artificial Intelligence.

Keywords: Neuroscience, Happiness, Artificial Intelligence, Bibliometric analysis.

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1. Introduction

Artificial intelligence (AI) is based on intelligent systems capable of analyzing large amounts of data, reproducing human behavior, and making simple or complex decisions. AI information can come from machine learning and deep learning, among other methods, and they can perform tasks automatically through algorithms. AI currently performs tasks with more pressure than humans and can be used in repetitive tasks. (1)

AI has brought about a paradigm shift in the understanding of human beings and the interaction with intelligent systems that increase the possibilities of obtaining complex results in real-time based on systems that act rationally and think like humans. The systems are now so diverse that they have applications in various areas of knowledge, for example, medicine. (2)

In recent years, there has been a convergence between AI and neuroscience, particularly in studying the brain and developing treatments for neurological disorders. Artificial neural networks and deep learning provide valuable insights into neural processing and brain functioning. (3)

*Corresponding author. Email: rolandoa.eslavaz@unilibre.edu.co

Research is trying to explain how neural processes influence an individual's happiness. Considering the complexity of happiness, neuroscience has identified several areas of the brain associated with it, for example, the reward system, which includes the neurotransmitter dopamine. [4]

AI plays a vital role in measuring happiness since tools such as functional magnetic resonance imaging (fMRI) and positron emission tomography (PET) provide insight into the brain activity that generates positive emotions, and research is finding that neural processes can influence human well-being. [5]

Given the above, this research aimed to evaluate the interaction between neuroscience and happiness based on the advances in Artificial Intelligence. In this sense, articles from 2013-2023 were obtained from the Scopus database; likewise, the Visualization of Similarities program (VOSviewer 1.6.18) was used for data analysis.

2. Methods

Bibliometric analysis steps were followed to study neuroscience and happiness with AI. The search filter considered titles, abstracts, and keywords. The search filter was: (TITLE-ABS-KEY (neuroscience) OR TITLE-ABS-KEY (happiness) AND TITLE-ABS-KEY ("artificial intelligence")) AND PUBYEAR > 2012 AND PUBYEAR < 2024 AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (PUBSTAGE , "final")))

We worked with articles published in English in the Scopus database from 2013-2023. In this sense, 603 documents were found.

A first analysis was carried out with the information provided by Scopus to generate analytical tables on the documents by year, country, and authors. [6]

Secondly, the Scopus CSV file was analyzed with VOSviewer. In this regard, co-citations, collaboration, and the occurrence of keywords were analyzed. The thesaurus file was also used to join common words and refine the results. [7]

3. Results

Since 2013, research on neuroscience and happiness using artificial intelligence has been increasing, as evidenced by the scientific output of the last three years, going from 91 papers in 2021 to 114 and 121 papers in 2022 and 2023 (Table 1).

Neuroscience is relying on AI to understand happiness from several angles. In recent years, neuroscience has been using functional magnetic resonance imaging to study happiness-related brain activity. AI is making it possible to detect patterns linked to positive emotions. Also, computational models that simulate the neural processes associated with happiness are being developed, allowing the prediction of stimuli that affect mood. [8]

AI makes it possible to analyze large amounts of data on human behavior and environmental factors to develop strategies and programs to improve human emotional well-being. Programs can use machine learning algorithms that adapt to the needs of individuals; for example, some programs are making it possible to monitor emotional states using biometric and behavioral signals to improve mental well-being.

Table 1. Documents by year

YEAR	DOCUMENTS
2023	121
2022	114
2021	91
2020	67
2019	47
2018	49
2017	19
2016	23
2015	17
2014	24
2013	31
TOTAL	603

Table 2 shows the top 10 papers by author, with Chirico, A. (4), Dumas, G. (4), and Fox, S. (4) occupying the first three places. Researchers are deepening the process of integrating neuroscience with AI to provide new perspectives to understand human happiness.

Table 2. Top 10 documents by author

N°	AUTHOR NAME	DOCUMENTS
1	Chirico, A.	4
2	Dumas, G.	4
3	Fox, S.	4
4	Novais, P.	4
5	Ramos, F.	4
6	Riva, G.	4
7	Ascoli, G.A.	3
8	Botvinick, M.	3
9	George, D.	3
10	Graña, M.	3

Egarding scientific output by country, the United States is in first place with 184 papers, followed by the United Kingdom (74) and China (73). Neuroscience has excellent potential with AI to provide new ways to explain human happiness and improve well-being. The study of happiness has gained space in different disciplines such as psychology, sociology, and economics; therefore, the neural basis of happiness and subjective well-being has been deepened from neuroscience (Table 3). [9]

Regarding scientific output by country, the United States is in first place with 184 papers, followed by the United Kingdom (74) and China (73). Neuroscience has excellent potential with AI to provide new ways to explain human happiness and improve well-being. The study of happiness has gained space in different disciplines such as psychology, sociology, and economics; therefore, the neural basis of

happiness and subjective well-being has been deepened from neuroscience. (10)

Research in developed countries seeks to better understand the factors that influence happiness to include measures and public policies that allow them to monitor society's progress to improve people's standard of living. (11)

Table 3. Top 10 documents by country

N°	COUNTRY/TERRITORY	DOCUMENTS
1	United States	184
2	United Kingdom	74
3	China	73
4	Germany	47
5	Italy	40
6	Japan	32
7	India	31
8	Spain	30
9	Canada	28
10	France	26

In terms of subject area, the first three places were found to be occupied by Computer Science (249), Neuroscience (182), and Engineering (101) (Table 4).

Despite the complexity of happiness, neuroscience has been studying the brain processes and neural bases associated with positive emotions, and other aspects that can be applied in different areas of medicine are being checked with the support of AI. (12)

Table 4. Top 10 subject area

N°	SUBJECT AREA	DOCUMENTS
1	Computer Science	249
2	Neuroscience	182
3	Engineering	101
4	Medicine	87
5	Arts and Humanities	78
6	Psychology	74
7	Social Sciences	66
8	Biochemistry, Genetics and Molecular Biology	55
9	Mathematics	48
10	Multidisciplinary	47

As for the leading institutions in scientific production, the first three places are occupied by CNRS Centre National de la Recherche Scientifique (15), University College London (13) and Harvard Medical School (11) (Table 5).

Internationally recognized institutions are developing research in neuroscience and happiness supported by AI. This area of knowledge, known as affective neuroscience or neuroscience of joy, is being studied from different points of view, for example, the psychology of gratitude, compassion, and altruism, among others. (13)

Table 5. Top 10 documents by affiliation

N°	AFFILIATION	DOCUMENTS
1	CNRS Centre National de la Recherche Scientifique	15
2	University College London	13
3	Harvard Medical School	11
4	Stanford University	11
5	University of Cambridge	11
6	Harvard University	10
7	New York University	10
8	Massachusetts Institute of Technology	10
9	University of California, San Diego	9
10	Zhejiang University	8

For the Co-Citations analysis, the most cited documents were analyzed for the 603 papers analyzed. Considering a minimum number of citations to the cited reference of 6 as a criterion revealed that out of 35467 citations, only 15 documents met the criterion. It should be noted that the thesaurus file was used to join two standard documents.

Table 6 shows the top 10 Co-Citations - cited references. The documents that received the most citations of the analyzed documents are from the authors Lecun et al. (35), Hassabis et al. (25), and Kahneman (12).

In this sense, four clusters revealed the Co-Citations among the papers. The first cluster identified with red color is integrated by the works of Gerstner et al. (2014), Lecun et al. (2015), Lecun et al. (1998), Roy et al. (2019), Rumelhart et al. (1986) and Schmidhuber (2015). The second cluster identified with the color green is integrated by the works of Friston (2010), Hassabis et al. (2017), Kahneman (2011), and Marr (1982). The third cluster identified with blue color is integrated by the works of Goodfellow (2015), Laird (2015), Newell (1990), and Schultz (1997). Finally, the fourth cluster identified with the yellow color is integrated by the work of Mnih et al. (2015), which is not linked to any other work.

Table 6. Top 10 de co-citations – cited references

N°	CITED REFERENCE	CITATIONS
1	Lecun et al., Deep learning, nature, 521, pp. 436-444, (2015)	35
2	Hassabis et al., Neuroscience-inspired artificial intelligence, neuron, 95, pp. 245-258, (2017)	25
3	Kahneman, Thinking, fast and slow, (2011)	12
4	Schmidhuber, Deep learning in neural networks: an overview, neural networks, 61, pp. 85-117, (2015)	10
5	Laird, The soar cognitive architecture, (2012)	9
6	Lecun et al., Gradient-based learning applied to document recognition, proc. ieee, 86, pp. 2278-2324, (1998)	9

7	Gerstner et al., Neuronal dynamics: from single neurons to networks and models of cognition, (2014)	8
8	Marr, Vision: a computational investigation into the human representation and processing of visual information, (1982)	8
9	Rumelhart et al., Learning representations by back-propagating errors, nature, 323, pp. 533-536, (1986)	8
10	Schultz et al., A neural substrate of prediction and reward, science, 275, pp. 1593-1599, (1997)	8

For the analysis of Co-Authorship Author - Authors, out of 594 authors, only 20 fulfilled the criterion. Table 7 reveals the top 10 co-authorship authors. The top three places are occupied by Kosinski et al. (2013), Roy et al. (2019), and Barrett et al. (2019).

The results reveal that there is no collaboration between the authors in this area of research. Therefore, the authors' lines of research are independent. It should be noted that there are a range of separate lines of research on neuroscience and happiness that are evolving with AI; among them are the neural basis of happiness, which investigates the brain regions associated with happiness, the neurochemistry of happiness, which studies the neurotransmitters and brain chemicals involved in the regulation of mood and the feeling of happiness, brain plasticity that examines the brain's ability to adapt and influence a person's capacity to experience happiness, brain connectivity that studies the functional connectivity between different regions of the brain and its relationship with happiness, among others.

Table 7. Top 10 de co-authorship author - authors

N°	AUTHOR	YEAR	CITATIONS
1	Kosinski et al.	2013	1681
2	Roy et al.	2019	813
3	Barrett et al.	2019	759
4	Pei et al.	2019	493
5	Huang	2015	394
6	Kim et al.	2014	325
7	Mairal et al.	2014	298
8	Wang et al.	2018	290
9	Laird et al.	2017	233
10	Prieto et al.	2016	201

For the Co-Authorship Author - Countries analysis, of 75 countries, only 20 met the criterion. The findings show that the top three places in Co-Authorship Author - Countries both by documents and citations are occupied by the United States (184/6064), United Kingdom (74/4456), and China (73/1081) (Table 8).

Table 8. Top 10 de co-authorship author - countries

N°	Country	documents	Country	citations
1	United States	184	United States	6064
2	United Kingdom	74	United Kingdom	4456
3	China	73	China	1081
4	Germany	47	Singapore	924
5	Italy	40	Spain	878
6	Japan	32	Germany	847
7	India	31	France	605
8	Spain	30	Switzerland	549
9	Canada	28	Canada	410
10	France	26	Austria	407

The collaboration of the countries is reflected in the formation of four clusters. The first cluster identified with the color red comprises Austria, China, Germany, India, Singapore, South Korea, Taiwan, and the United States. The second cluster identified with green includes Italy, the Netherlands, Portugal, the Russian Federation, Spain, and Switzerland. The third cluster identified with blue comprises Australia, Canada, France, Japan, and the United Kingdom. The fourth cluster identified with the yellow color is integrated only by Malaysia, so it is evident that this country has no collaboration with any other country. (Figure 1).

Although research in neuroscience and happiness is a developing field, there is an emerging collaboration and participation in research projects. International organization's academic collaboration between universities promotes cooperation between countries to develop research projects.

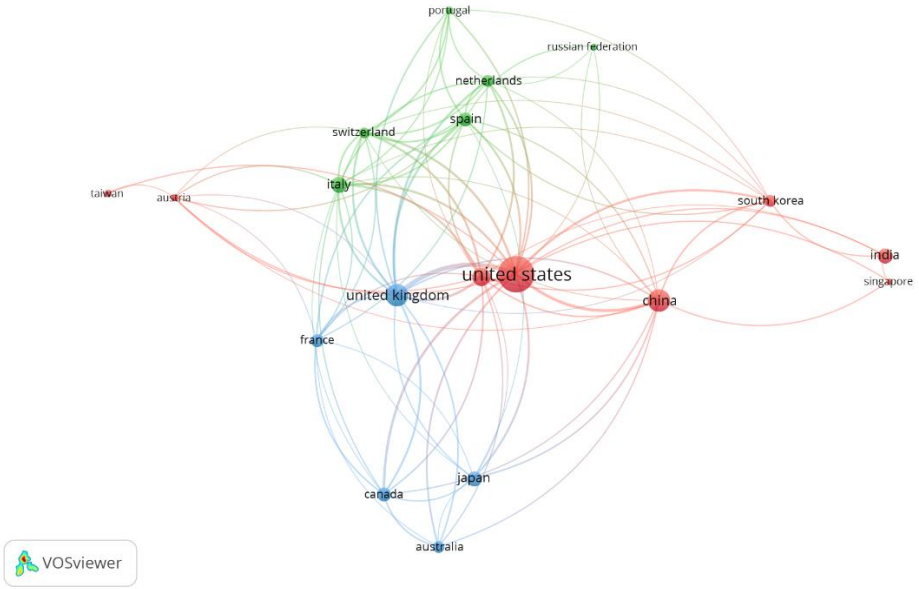

Figure 1. Co-authorship author - countries

For the study of the Co-occurrence of All Keywords, out of 5198 keywords, only 19 words met the criterion. It should be noted that 5 common words were joined with thesaurus, and 2 words that had nothing to do with the study were eliminated.

Three clusters were generated based on how the words are associated and appear together in the documents. The first cluster, identified in red, comprises the phrases artificial intelligence, brain, cognition, deep learning, learning systems, machine learning, neurology, neuroscience, and robotics.

The second cluster is identified with the color green and comprises the words Adult, Controlled Study, Emotion, Female, Human, Human Experiment, Male, and Physiology. The third and last cluster, identified with the color blue, comprises Algorithms and Nonhumans (Figure 2).

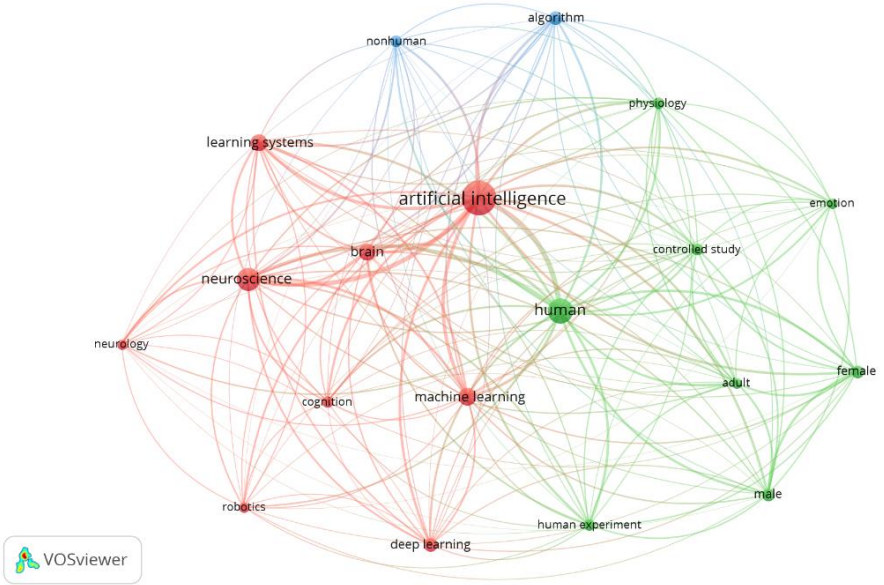

Figure 2. Co-ocurrence all keywords

4. Discussion

In the Co-occurrence - Author Keywords analysis, out of the 1991 keywords, only 17 met the criterion. In this regard, 6 common words were joined with thesaurus (Figure 3).

Three clusters were formed. The first cluster identified with red is related to AI applications for predicting happiness. The cluster comprises Deep Learning, EEG, Emotion Recognition, Learning, Machine Learning, Reinforcement Learning and Robotics.

AI has immense potential to improve people's well-being. In 2019, an artificial intelligence model was used to create a Happiness Index, and the results of the study coincided with several indicators established in the World Happiness Report related to freedom, income, trust, generosity, social support, and healthy life expectancy. (14) (15) In addition, other AI studies have looked at facial features to identify a person's feelings in certain situations. (11) (16) (126-127)

AI initiatives have emerged to solve various human problems such as poverty, human rights, or education using facial recognition, Convolutional or Recurrent Neural Networks, Computer Vision, and Natural Language Processing, among others. (17) (18)

Chatbots and Robots are essential support to psychologists, thanks to their interaction with older adults and intelligent interaction; also, depending on the algorithm, these tools can monitor the behavior patterns of autistic people or people with Alzheimer's disease. (19) (20)

AI is being applied in the workplace to generate happiness, based on the study of the times when employees get up, interact with each other, people and interact; thus, with the analysis of behavior patterns, recommendations are generated to establish the times of the day when people should interact to promote happiness, but also, with AI, repetitive processes are optimized to free up time for creative activities and achieve performance at work. (21) (22)

From the above, it can be said that AI has been integrated into people's lives in different ways; for example, with the algorithms of virtual assistants such as Alexa, Google Assistant, or Netflix, people's tasks are being facilitated, and their life experiences are being improved. (8) (23)

The second cluster, identified with the color green, is related to AI tools in neuroscience. This cluster is integrated with Artificial Intelligence, Big Data, Cognitive Neuroscience, Computational Neuroscience, Computer Vision, and Ethics.

Neuroscience is presenting essential advances with the use of AI that are benefiting patients. Neuroscience research has enabled the development of advanced techniques such as Electroencephalography (EEG) and Functional Magnetic Resonance Imaging (fMRI) supported by AI, making it possible to understand large amounts of brain data to classify patterns and establish correlations. (13) (5)

Brain imaging studies with AI provide insight into changes in brain structures and clinical symptoms that favor early detection and interventions. (24) Likewise, AI allows the analysis of a person's medical history and genetics, among other factors that facilitate the treatment of patients. (25) (26)

AI tools such as Machine Learning and Deep Learning, among others, are making it possible to understand the brain and improve the treatment of psychological disorders; however, there is a significant concern to be resolved, and it is related to data protection and the guarantee of privacy; therefore, the informed consent of patients in the study should be guaranteed as far as possible, and the information obtained should be anonymized as far as possible. (10) (27)

The third and last cluster identified with the blue color is related to neuroscience in psychology. This cluster is integrated by the words Brain, Consciousness, Neural Networks, and Neuroscience.

Neuroscience helps to explain how the development of the nervous system in childhood affects people's cognitive abilities throughout their lives, and it is also possible to predict the reaction of patients to specific drugs suggested in therapies thanks to magnetic resonance imaging or electroencephalogram. (28) (29)

Neuroscience and psychology, with the study of the brain and the mind, help to understand how human beings construct and process information. These influence their behaviors, emotions, feelings, and reactions to external stimuli. (30) (12)

In this sense, there are several standard fields of research, among which are cognitive neuroscience (focuses on explaining how the brain acquires, processes, and uses information), research in clinical psychology (discoveries are obtained in the social relationships of individuals and help them overcome mental disorders), research in social psychology (studies the factors that influence the feelings and beliefs of individuals about other people), among others. (31) (32)

Therefore, neuroscience helps psychology to understand the development of the human nervous system at different stages of their lives to know how they determine their behavior. In this sense, AI is enabling more accurate imaging examinations and the treatment of diseases affecting the nervous system. (33)

Neuroscience in psychology allows understanding of how the brain behaves and influences emotions and behaviors; it also enables the development of psychological theories with a more biological foundation since behavior is currently being linked to brain activity in real-time thanks to tools such as functional magnetic resonance imaging (fMRI) and electroencephalography (EEG). The integration of these two areas of knowledge facilitates the understanding of the human mind, both theoretically and practically. (34)

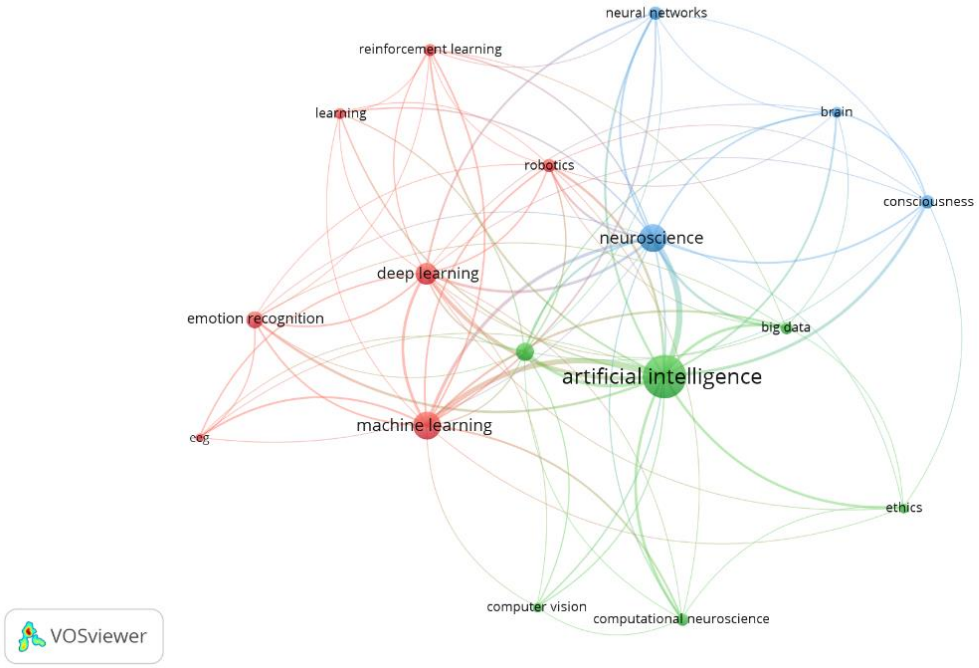

Figure 3. co-ocurrence – author keywords

The current research trend of the Network shows a strong interest in Deep Learning and Artificial Intelligence; however, to reach this point, research has studied emotion recognition and neuroscience (Figure 4).

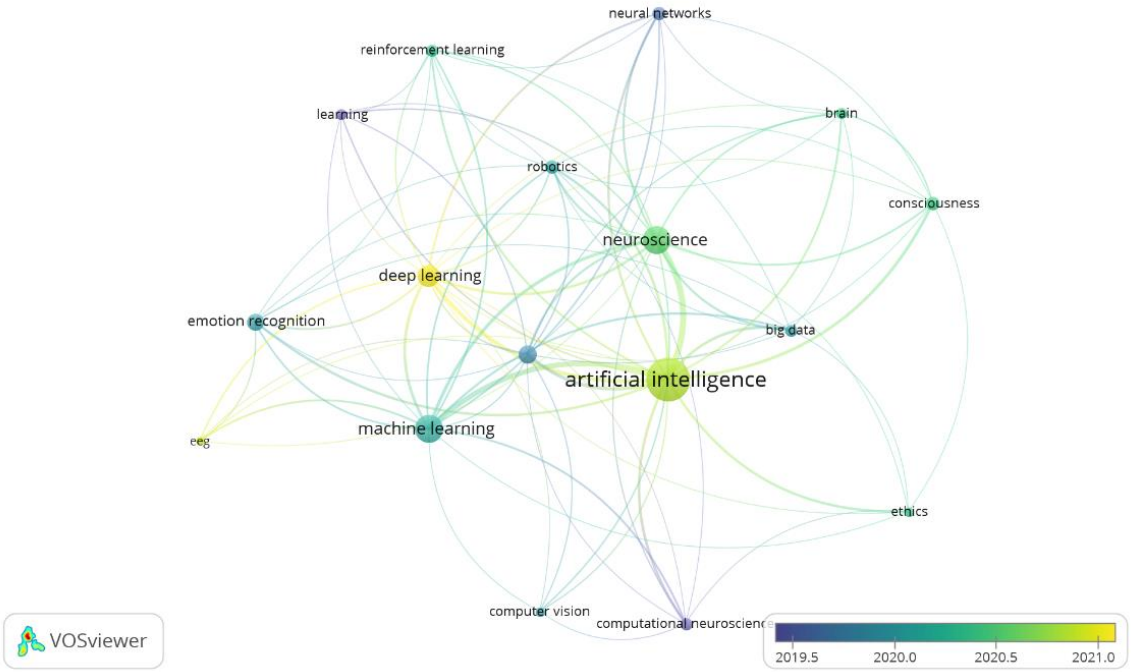

Figure 4. Overley of co-ocurrence - author keywords

5. Conclusiones

Neuroscience research has significantly improved our understanding of mental processes such as emotions and consciousness. Neuroscience has encountered happiness and is opening up to an evidence-based approach to understanding human well-being supported by AI.

Neuroscience is delving deeper into the neural and biological mechanisms related to happiness. It has been shown that happiness is associated with specific brain regions, for example, the prefrontal cortex. Happiness releases neurotransmitters such as dopamine and serotonin, which regulate mood. Also, connections between brain regions, such as the prefrontal cortex and the limbic system, influence happiness.

In this sense, AI is becoming an excellent tool to accurately measure and improve people's well-being. Algorithms are making it possible to obtain information on changes in tone of voice, facial expressions, and emotions, among others, which makes it easier for professionals to create a more efficient and accurate diagnosis.

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