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SYSTEMATIC REVIEW

Magnetic resonance imaging in mood disorders: a bibliometric analysis from 1999 to 2020

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Abstract

Objective Globally, mood disorders are highly prevalent, and are associated with increased morbidity and mortalities. Magnetic resonance imaging is widely used in the study of mood disorders. However, bibliometric analyses of the state of this field are lacking.

Methods A literature search in the web of science core collection (WoSCC) for the period between 1945 and 2020 returned 3073 results. Data extracted from these publications include, publication year, journal names, countries of origin, institutions, author names and research areas. The bibliometric method, CiteSpace V and key words analysis were used to visualize the collaboration network and identify research trends, respectively.

Results Since it was first reported in 1999, the use of magnetic resonance imaging in studies on mood disorders has been increasing. Biological psychiatry is the core journal that has extensively published on this topic, while the UNIV PITTSBURGH, USA, has the highest published papers on this topic. Keyword analysis indicated that studies on depression, bipolar disorders, and schizophrenia, with a focus on specific brain regions, including amygdala, prefrontal cortex and anterior cingulate cortex are key research topics.

Conclusion Brain structure and network, sex differences, and treatment-associated brain changes are key topics of future research.

Keywords Mood disorders · Depression · Anxiety · Citespace · f-MRI

Introduction

Mood disorders are a class of psychiatric conditions that alter moods, energy and motivation. This group of disorders include depression, bipolar disorder, premenstrual syndrome, premenstrual dysphoric disorder, and the autism spectrum of disorders among others. Globally, mood disorders affect > 300 million people with devastating consequences [1, 2]. Previous studies have reported the clinical prevalence of mood disorders [3, 4], with children, adolescents, elderly people and patients with neurological conditions being prone to depressive disorders [5, 6]. The pathophysiology of mood disorders is complex and not properly elucidated [7, 8]. Moreover, it is influenced by genetic and environmental factors that may disrupt neurotransmitter homeostasis [7, 8]. Therefore, mood disorders may result from negative feelings that leave a lasting influence on mental processes associated with perception, cognition and motor systems [9, 10]. In affective disorders, brain morphological alterations largely occur on the fronto-limbic cortex, hippocampus and amygdala. These structures modulate an individual's emotional and cognitive function, and mood disorder manifestation [11]. Neuroimaging has revealed that brain networks that control emotional behaviors can also influence mood disorder pathophysiology [12]. Advances

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in in vivo neuroimaging techniques have, therefore, greatly improved our understanding of mood disorder pathophysiology [13].

There are various clinical imaging techniques, such as PET, DTI [14], ASL [15], and 1H-MRS [16]. However, magnetic resonance imaging (MRI), one of the neuroimaging techniques that are widely used in neuroscience to visualize neural activities, and to identify mental disease biomarkers [17] has unique advantages. In particular, MRI is now widely used to evaluate mood disorders [18, 19], such as depression [20] and premenstrual dysphoric disorder [21]. Advances in this technology will enable quantification of biochemical components of a functioning brain that are not detectable [22]. However, despite progress in the use of MRI to study mood disorders, accompanying bibliometric analysis is lacking.

Bibliometrics is a statistical analysis and quantitative tool for identifying research hotspots and frontiers in a particular field within a short time by extracting quantitative information on study distributions by country/region, institution, author, and journal [23]. Now, bibliometric methods in Citespace have been widely used in medical fields, such as acupuncture [24] and regenerative medicine [25]. The CiteSpace software was invented by Professor Chaomei Chen in early 2004. It is based on scientometrics and knowledge visualization, and is effective in mining scientific literature for critical information. It is used to establish co-occurrence network maps of authors, keywords, institutions, countries, and subject categories as well as co-citation networks of cited authors, cited references, and cited journals. For any discipline of interest, CiteSpace can greatly inform on basic knowledge, identify seminal studies in the area, uncover current research themes, and contextualize research advances [26].

Therefore, this study aimed at comprehensively analyzing the current status and developing trends of related references derived from Web of Science database from 1999 to 2020 in global research on mood disorders by magnetic resonance imaging through a bibliometric and visual analysis.

Materials and methods

Data collection and screening

Online literature search was performed in web of science core collection (WoSCC). To minimize bias from daily database updates, the search was done on the same day (April 29th, 2020) using the following search terms: (TS = (Disorder, Mood) OR TS = (Disorders, Mood) OR TS = (Mood Disorder) OR TS = (Affective Disorders) OR TS = (Affective Disorder) OR TS = (Disorder, Affective) OR TS = (Disorders, Affective)) AND ((Functional MRI) OR TS: (Functional MRIs) OR TS: (MRIs, Functional) OR TS: (Functional Magnetic Resonance Imaging) OR TS: (Magnetic Resonance Imaging, Functional) OR TS: (Spin Echo Imaging) OR TS: (Echo Imaging, Spin) OR TS: (Echo Imagings, Spin) OR TS: (Imaging, Spin Echo) OR TS: (Imagings, Spin Echo) OR TS: (Spin Echo Imagings) OR TS: (Imaging, Magnetic Resonance) OR TS: (NMR Imaging) OR TS: (Imaging, NMR) OR TS: (Tomography, NMR) OR TS: (Tomography, MR) OR TS: (MR Tomography) OR TS: (NMR Tomography) OR TS: (Steady-State Free Precession MRI) OR TS: (Steady-State Free Precession MRI) OR TS: (Zeugmatography) OR TS: (Imaging, Chemical Shift) OR TS: (Chemical Shift Imagings) OR TS: (Imagings, Chemical Shift) OR TS: (Shift Imaging, Chemical) OR TS: (Shift Imagings, Chemical) OR TS: (Chemical Shift Imaging) OR TS: (Tomography, Proton Spin) OR TS: (Proton Spin Tomography) OR TS: (Magnetization Transfer Contrast Imaging) OR TS: (MRI Scans) OR TS: (MRI Scan) OR TS: (Scan, MRI) OR TS: (Scans, MRI) OR TS: (fMRI) OR TS: (MRI, Functional)) AND Literature type: (Article), Indices = SCI-EXPANDED, SSCI, CCR-EXPANDED, IC time span = all years. Only published articles were selected, and publication language was unrestricted (Fig. 1).

Through descriptive analysis, we characterized the selected studies by publication year, country, journal, and authors and then constructed knowledge maps using the CiteSpace software (version 5.3.R4). Finally, citation growth rate or keywords were evaluated using burst in CiteSpace V.

Results and discussion

General information of publications

Due to its quality curation of research studies, WoS is a reliable source of studies for bibliometric analysis of scientific literature [27, 28]. Our first round of literature search found 54,346 and 331,162 reports on mood disorders and MRI, respectively. Among them, a total of 3073 original publications involving MRI in mood disorder studies were selected for further analysis. There was an increase in the number of publications on this topic between 1999 (28) and 2019 (236). Notably, in the last 4 months of 2020, 66 original studies were published (Fig. 2a). Citation scores of these studies for the 1999 (16) and 2019 (14,915) years exhibited a significant increase. An increase in citation scores by 4039 resulted in a total score of 142,188, with an h-index of 166 and on average, 46.27 references per item (Fig. 2b). These results indicate that MRI is increasingly becoming popular as a mood disorder research tool.

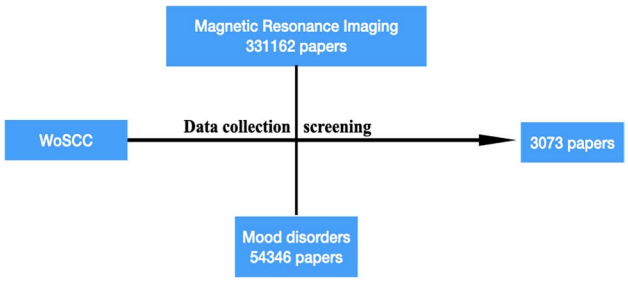

Fig. 1 Schematic diagram of data collection and screening methods

Funding analysis

Adequate research funding is crucial for scientific advancement and development of future researchers [29]. Research grant applications is critical in advancing one's academic career [30]. The 3073 published studies included in this study were supported by a total of 2976 grants. The top 10 funders were United States department of health human services (1000), NIH (999), NIH national institute of mental health (NIMH) (651), national natural science foundation of China (193), Narsad (151), German research foundation (DFG) (148), medical research council (MRC), UK (138), NIH national center for research resources NCRR (114), NIH national institute on drug abuse (NIDA) (76) and Wellcome trust (75) (Table 1). Among the top 10 funders, six are American. Prior to world war II, public research funding was scarce, and was mainly directed at aeronautical and agricultural research. Recently, improved government funding has accelerated basic research, including in China.

Journal analysis

Journal analysis simplifies identification, tracking, and focus on relevant research in topics of interest. The 3073 studies included in this study are published in 467 different journals. Among them, 185 studies are in biological psychiatry, 175 studies are in the journal of affective disorders, 169 studies are in psychiatry research, 169 studies are in neuroimaging, 103 studies are in neuroimage, 102 studies are in bipolar disorders, 76 studies are in psychological medicine, 72 studies are in human brain mapping, 72 studies are in PLos one, and 69 studies are in the American journal of psychiatry.

CiteSpace journal co-citation analysis identified 1029 highly cited journals and 10,270 network lines. Biological psychiatry was the most cited journal (Fig. 3). Moreover, Biological psychiatry, Neuroimage, American journal of psychiatry, Archives of General Psychiatry, and Journal of neuroscience published many groundbreaking studies that influenced research direction (Tables 2and3). Biological psychiatry is society of biological psychiatry's official journal that is geared towards enhancing research excellence in areas studying the nature, causes, mechanisms, and management of thought, emotion, or behavioral disorders. Biological psychiatry is highly regarded in psychiatric neuroscience and was ranked 2nd among psychiatric journals in 2019 by google scholar, with an impact factor of 7.27.

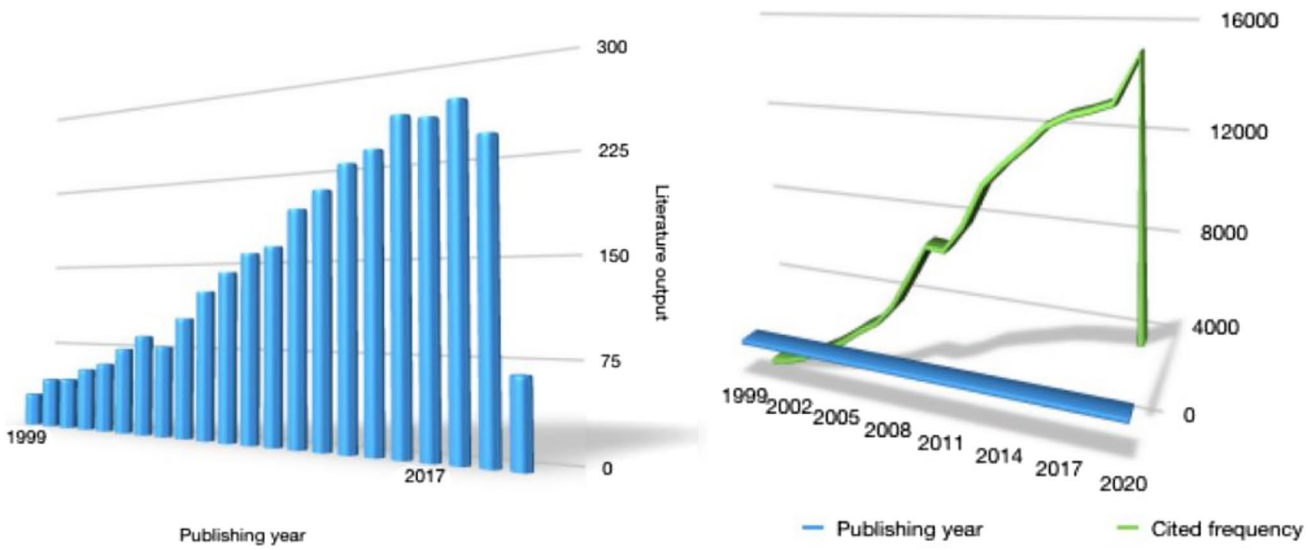

Fig. 2 Literature outputs involving MRI in mood disorder studies and their citation frequency between 1999 and 2020

Table 1 Funding agencies of the 3073 publications reporting MRI use in mood disorder studies

Rank	Funding institutions	Country	Records	% of 3073
1	United States Department of Health Human Services	USA	1000	32.541
2	National Institutes of Health NIH USA	USA	999	32.509
3	NIH National Institute of Mental Health NIMH	USA	651	21.185
4	National Natural Science Foundation of China	China	193	6.281
5	NARSAD	USA	151	4.914
6	German Research Foundation DFG	German	148	4.816
7	Medical Research Council UK MRC	UK	138	4.491
8	NIH National Center for Research Resources NCRR	USA	114	3.71
9	NIH National Institute on Drug Abuse NIDA	USA	76	2.473
10	Wellcome Trust	UK	75	2.441

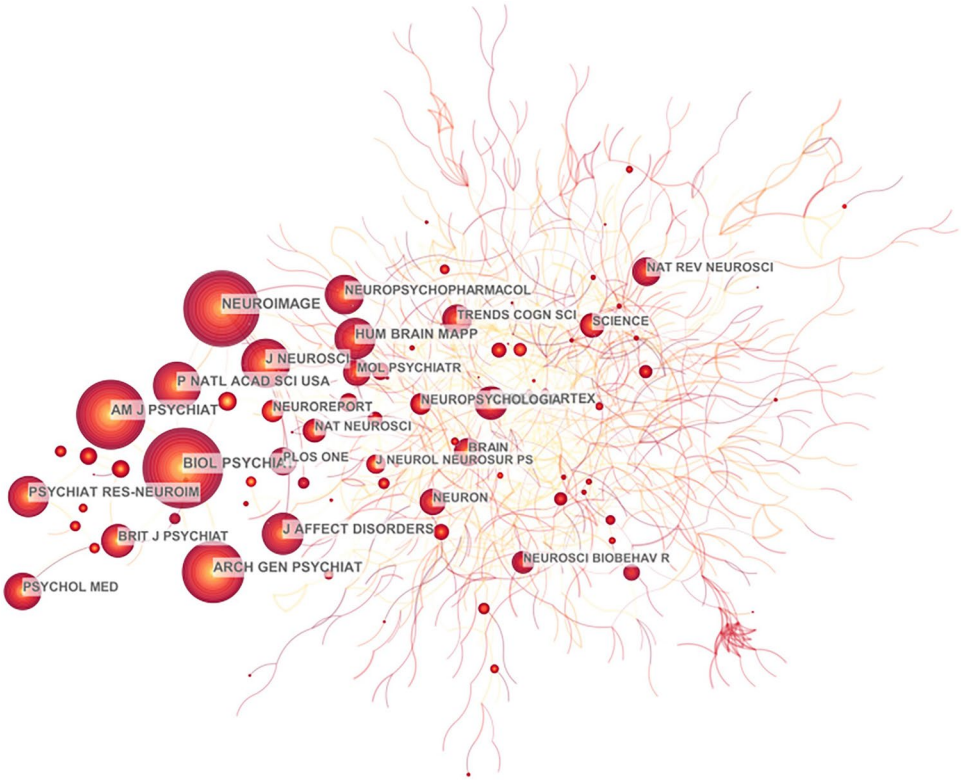

Fig. 3 Journal co-citation network visualization

Scientific Research Collaboration Analysis

Research collaboration is crucial in interdisciplinary research and helps overcome scientific challenges, leading to major research breakthroughs. Research collaboration network refers to the appearance of authors from different research institutions, or countries (regions) in the same paper.

Author analysis

CiteSpace analysis uncovered 919 nodes (corresponding to 919 prolific authors), and 1642 cooperative lines, indicating intense collaboration between authors (Fig. 4). Node size is directly proportional to the number of publications, while connecting line thickness is directly proportional to the level of collaboration. Phillips ML was the most productive author, with 59 publications, followed by Soares JC (54), Pine DS (48), Brambilla P (44), Drevets WC (42), Leibenluft E (40), Heinz A (33), Keshavan MS (33), Strakowski SM(32) and Birmaher B (31).

Table 2 Top 10 journals involving MRI use in mood disorder studies

Rank	Journal	记录	% of 3073	CiteScore
1	Biological Psychiatry	185	6.024	7.27
2	Journal of Affective Disorders	175	5.698	4.20
3	Psychiatry Research Neuro-imaging	169	5.503	2.70
4	Neuroimage	103	3.354	6.13
5	Bipolar Disorders	102	3.321	4.27
6	Psychological Medicine	76	2.475	5.77
7	Human Brain Mapping	72	2.345	5.11
8	Plos One	72	2.345	3.02
9	American Journal of Psychia-try	69	2.247	6.03
10	Neuropsychopharmacology	67	2.182	6.22

Table 3 Top 10 Cited journals related to MRI use in mood disorder studies

Rank	Journal	Freq	CiteScore	Country or region of publi-cation
1	Biol Psychiat	2573	7.27	United States
2	Neuroimage	2417	6.13	United States
3	Am J Psychiat	2243	6.03	United States
4	Arch Gen Psychiat	2057	0.00	United States
5	J Neurosci	1694	5.83	United States
6	P Natl Acad Sci USA	1606	8.58	United States
7	Psychiat Res-Neuroim	1468	2.70	Netherlands
8	Hum Brain Mapping	1458	5.11	United States
9	J Affect Disorders	1441	4.2	Netherlands
10	Neuropsychopharmacol	1353	6.22	England

Co-author networks are used to analyze joint research in any field of interest. We found a total of 1029 highly cited authors and 1468 network lines, with Drevets WC being top, with 761 co-authorships (Fig. 5, Table 4).

Country analysis

CiteSpace analysis identified 57 countries and regions, with 70 collaboration links (Fig. 6), indicating high cross-country (region) research links. Top countries by publication numbers were USA, Germany, England, China, Canada, Italy, Netherlands, Australia, Brazil and Switzerland. Interestingly, while Germany is the 2nd (481 publications), no German institutions are in the top 10 list of institutions (Fig. 6, Table 5).

Institutional analysis

CiteSpace analysis identified 40 research institutions and nine collaborations in the co-institute network. Based on the number of publications, the top 10 institutions were University of Pittsburgh, Harvard University, NIMH, King's College London, University of California, Los Angeles, Stanford University, Yale University, University of California San Diego, University of Sao Paulo and McLean Hospital (Fig. 7, Table 5).

Research area analysis

The studies included covered a total of 50 research fields, including immunology (171), followed by cell biology (65), and biochemistry-molecular biology (60). The top 20 research fields involving MRI use in mood disorders are

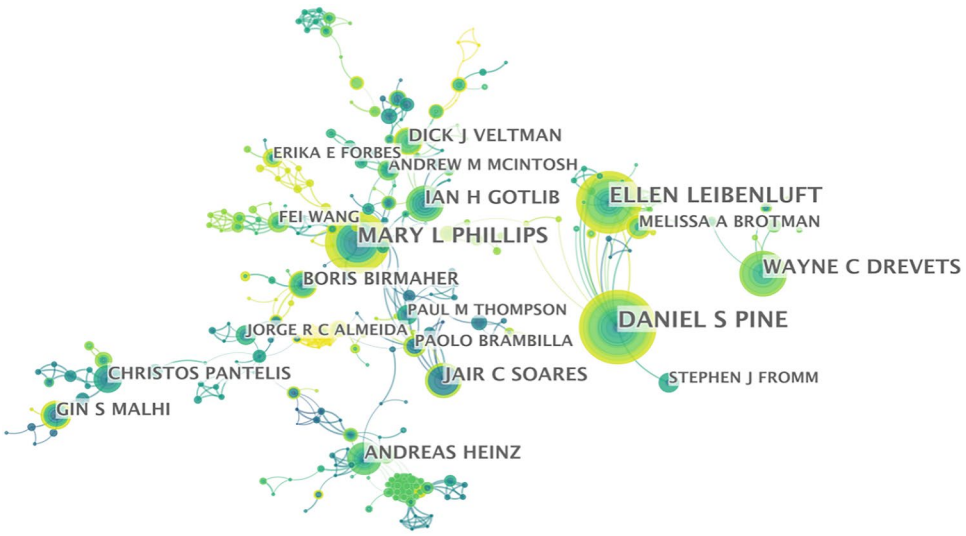

Fig. 4 Author journal co-citation network visualization

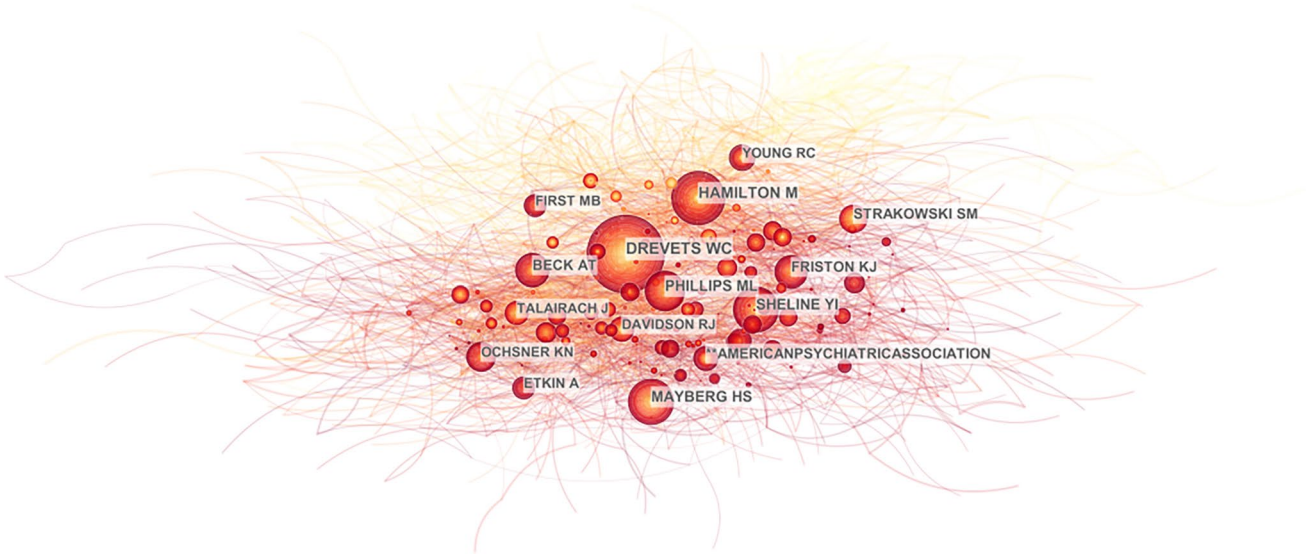

Fig. 5 Author co-citation network visualization

Table 4 Top 10 authors reporting MRI us in mood disorder studies

Rank	Author	Records	%	Rank	Cited-Author	Freq	Year
1	Phillips ML	59	1.92	1	Drevets WC	761	1999
2	Soares JC	54	1.757	2	Hamilton M	556	1999
3	Pine DS	48	1.562	3	Mayberg HS	507	1999
4	Brambilla P	44	1.432	4	Sheline YI	498	2000
5	Drevets WC	42	1.367	5	Phillips ML	454	2003
6	Leibenluft E	40	1.302	6	Beck AT	387	1999
7	Heinz A	33	1.074	7	Friston KJ	386	1999
8	Keshavan MS	33	1.074	8	Strakowski SM	359	1999
9	Strakowski SM	32	1.041	9	American Psychiatric Association	349	1999
10	Birmaher B	31	1.009	10	Young RC	311	2003

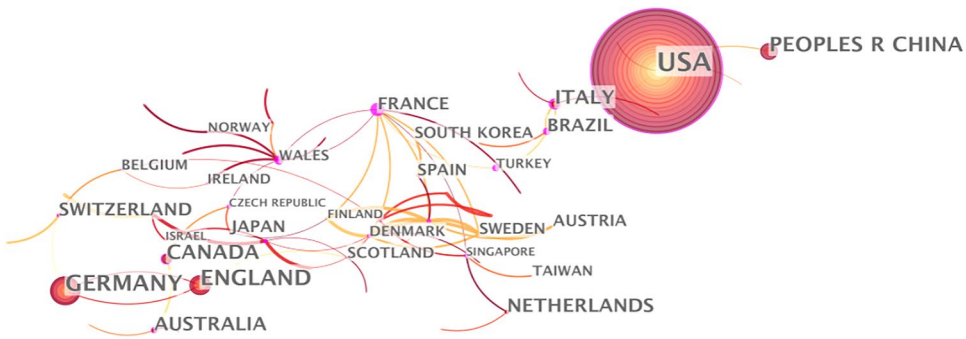

Fig. 6 Country network visualization

shown in Table 6. Neurosciences, neurology and psychiatry were the main research areas (Table 6).

Cited reference analysis

Analysis of cited reference co-citation identified 324 nodes and 555 links (Fig. 8). The top 10 cited publications on

Table 5 Top 10 countries and institutions using MRI in mood disorder research

Rank	Country/Region	Records	% of 3073	Rank	Institution	Country	Records	% of 3073
1	USA	1538	50.049	1	Univ Pittsburgh	USA	171	5.565
2	Germany	481	15.652	2	Harvard Univ	USA	139	4.523
3	England	372	12.105	3	NIMH	USA	129	4.198
4	Peoples R China	287	9.339	4	Kings Coll London	England	116	3.775
5	Canada	225	7.322	5	Univ Calif Los Angeles	USA	99	3.222
6	Italy	194	6.313	6	Stanford Univ	USA	98	3.189
7	Netherlands	170	5.532	7	Yale Univ	USA	98	3.189
8	Australia	162	5.272	8	Univ Calif San Diego	USA	74	2.408
9	Brazil	117	3.807	9	Univ Sao Paulo	Brazil	74	2.408
10	Switzerland	109	3.547	10	Mclean Hosp	USA	68	2.213

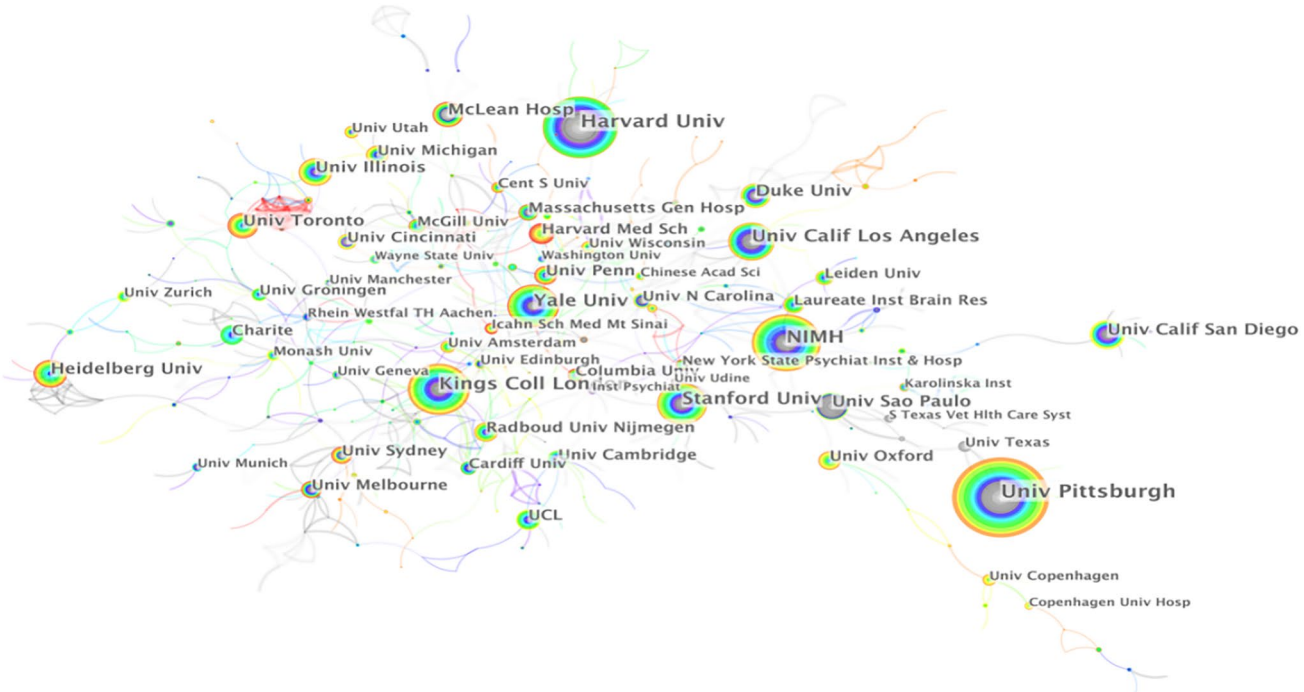

Fig. 7 Institution network visualization

MRI use in mood disorders focused on depression, schizophrenia and post traumatic stress disorder. With a citation frequency of 123, "Brain Structural and Functional Abnormalities in Mood Disorders: Implications for Neurocircuitry Models of Depression", ranked first (Table 7).

Research hotspots and frontiers

Within any given time period, knowledge maps of keywords co-occurrence reflect hot topics, while trending keywords indicate frontier topics. We used CiteSpace V to evaluate keywords in titles, abstracts, as well as article keyword sections, and to build keyword co-occurrence networks.

Research hotspots

Keyword visual knowledge map analysis revealed 130 nodes and 431 links (Fig. 9). With the strongest citation burst keywords being: f-MRI, depression, bipolar disorder, amygdala, mood disorder, prefrontal cortex, brain, major depression, schizophrenia, MRI, emotion, disorder, functional connectivity, meta-analysis, activation, abnormality, major depressive disorder, mood, anterior cingulate cortex, and magnetic resonance imaging (Table 8).

Table 6 Research areas for the 3073 publications on MRI use in mood disorder studies

Rank	Research direction	Records	% of 3073
1	Neurosciences neurology	1925	62.642
2	Psychiatry	1741	56.655
3	Psychology	471	15.327
4	Radiology nuclear medicine medical imaging	204	6.638
5	Pharmacology pharmacy	194	6.313
6	Behavioral sciences	135	4.393
7	Science technology other topics	130	4.23
8	Pediatrics	65	2.115
9	Biochemistry molecular biology	58	1.887
10	Geriatrics gerontology	42	1.367
11	General internal medicine	39	1.269
12	Endocrinology metabolism	37	1.204
13	Research experimental medicine	35	1.139
14	Substance abuse	27	0.879
15	Surgery	20	0.651
16	Rheumatology	15	0.488
17	Anatomy morphology	14	0.456
18	Genetics heredity	13	0.423
19	Physiology	13	0.423
20	Gastroenterology hepatology	12	0.39

Key diseases of mood disorders

Individuals experience various emotions, such as sadness, irritation, happiness, and elation. However, people with mood disorders often experience strong emotions, for unusually long periods of time to the extent that emotions negatively impact their daily routines. Depression and bipolar disorders are the main mood disorders. Our analysis revealed 658 and 570 studies on depression and bipolar disorder, respectively. Depression is a significant clinical and public health concern [31] and its pathophysiology has not been clearly elucidated. Environmental as well as cellular and molecular factors trigger functional, and/or structural brain alterations [32] that may contribute to these disorders. Cognitive behavioral therapy is the best-studied psychotherapeutic approach, although its mechanisms of action are unknown [33]. Bipolar disorder is characterized by recurrent episodes of elevated moods and depression, along with changes in activity levels. Bipolar (affective) disorder, (previously manic depressive illness) is extremely difficult to manage [34]. Additionally, major depression and schizophrenia are major research topics. Schizophrenia is a heterogeneous psychiatric disorder with wide-ranging clinical and biological manifestations [35].

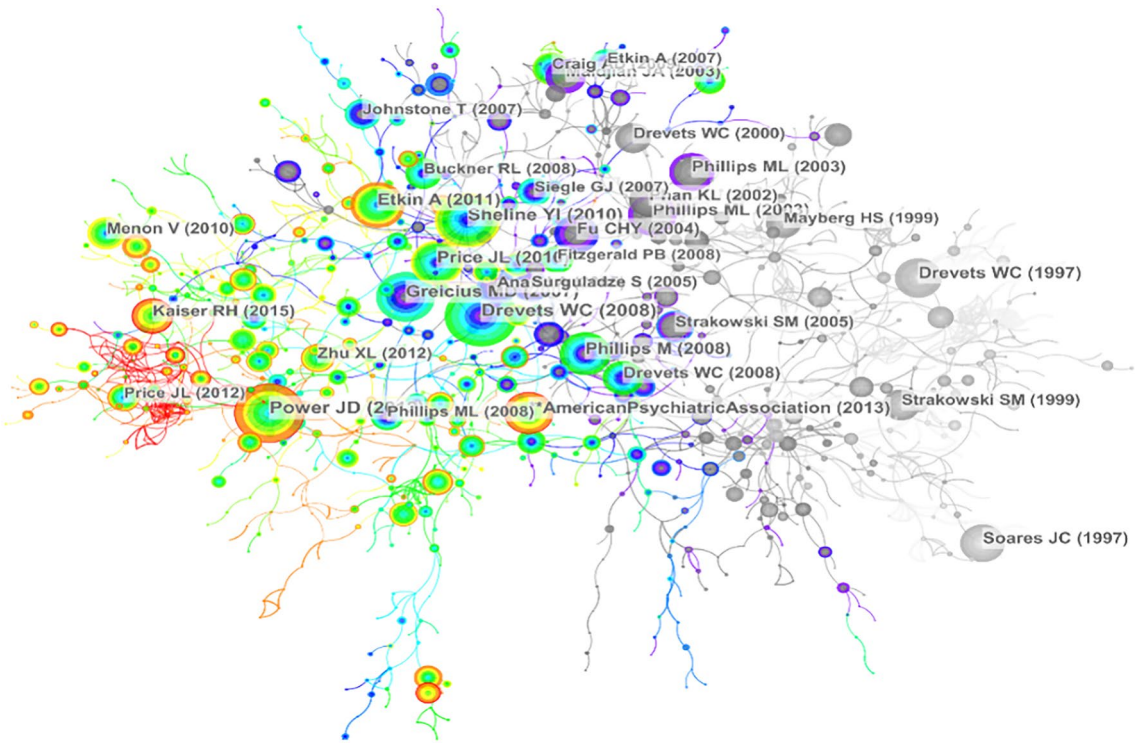

Fig. 8 Reference co-citation map for MRI-associated mood disorder studies

Table 7 Top 10 cited publications reporting MRI use in mood disorder studies

Year	Title	Source	Author	Freq	Burst	Degree
2008	Brain Structural and Functional Abnormalities in Mood Disorders: Implications for Neurocircuitry Models of Depression	Brain Struct Funct	Drevets WC	123	28.46	2
2012	Spurious but Systematic Correlations in Functional Connectivity MRI Networks Arise From Subject Motion	Neuroimage	Power JD	121	31.96	6
2010	Resting-state Functional MRI in Depression Unmasks Increased Connectivity Between Networks via the Dorsal Nexus	P Natl Acad Sci USA	Sheline YI	112	20.51	8
2007	Resting-state Functional Connectivity in Major Depression: Abnormally Increased Contributions From Subgenual Cingulate Cortex and Thalamus	Biol Psychiat	Greicius MD	104	24.1	4
2011	Emotional Processing in Anterior Cingulate and Medial Prefrontal Cortex	Trends Cogn Sci	Etkin A	93	22.46	4
2010	Neurocircuitry of Mood Disorders	Neuropsychopharmacol	Price JL	92	15.28	3
2008	A Neural Model of Voluntary and Automatic Emotion Regulation: Implications for Understanding the Pathophysiology and Neurodevelopment of Bipolar Disorder	Mol Psychiatr	Phillips M	88	16.1	1
2003	Neurobiology of emotion perception II: implications for major psychiatric disorders	Biol Psychiat	Phillips ML	86	29.2	3
2013	Diagnostic and Statistical Manual of Mental Disorders (DSM)	Diagn Stat Man Ment	American Psychiatric Association	86	29.21	2
1997	Subgenual Prefrontal Cortex Abnormalities in Mood Disorders	Nature	Drevets WC	83	42.41	6

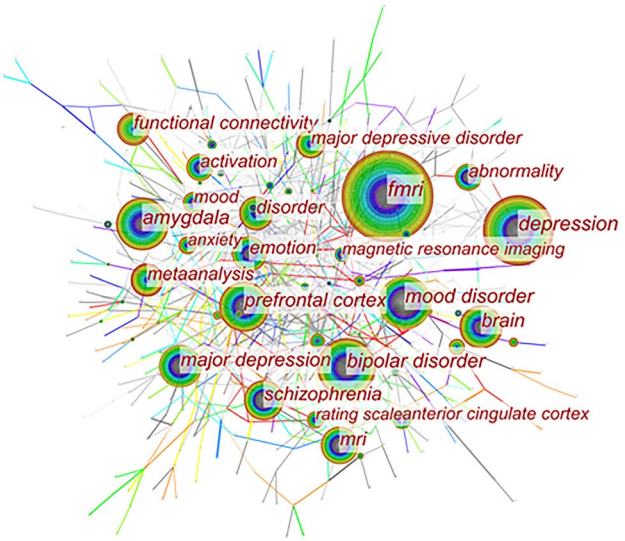

Fig. 9 Keyword co-occurrence map of MRI use in mood disorder studies from 1999 to 2020. Node size represents keyword co-occurrence frequency. Node size corresponds to keyword frequency

Key brain regions associated with mood disorders

Neuroimaging is increasingly becoming important in the study of the pathophysiology of mood disorders, with most studies focusing on the amygdala, prefrontal cortex and anterior cingulate cortex. The involvement of amygdala in major depression pathogenesis has been reported in previous studies [36]. While amygdala volume alterations have been implicated in mood disorders [37], Tomas et al. suggested that amygdala volume changes may reflect underlying illness or represent artifacts from medication or comorbidities [38]. The prefrontal cortex (PFC), which is involved in thinking and behavioral regulation has also been implicated in depression [39, 40]. Based on anatomical connectivity and functional specialization, the prefrontal cortex is divided into two subregions: ventromedial prefrontal cortex (vmPFC) and dorsolateral sectors (dlPFC) [41]. The human anterior cingulate cortex (ACC) is involved in response to pain affecting oneself, or others. However, its mechanisms of activity are poorly understood [42]. The mean gray matter volume of the "subgenual" ACC (sgACC) cortex is abnormally low in individuals with major depressive disorder (MDD) and bipolar disorder [43]. Psychopathic traits have been negatively correlated with amygdala-ventral anterior cingulate cortex connectivity for angry versus neutral faces [44]. The anterior cingulate cortex may influence initiation, motivation, and goal-directed behaviors [45].

Research frontiers

Keyword bursts provide a means of forecasting research direction. CiteSpace V analysis of burst keywords revealed 209 burst terms and 40 keywords by the end of 2020, and predicted the research hotspots shown in Fig. 10.

Table 8 Top 20 keywords of magnetic resonance imaging in mood disorders

Rank	Keyword	Freq	Rank	Keyword	Freq
1	fMRI	862	11	Emotion	372
2	Depression	658	12	Disorder	365
3	Bipolar disorder	570	13	Functional connectivity	342
4	Amygdala	530	14	Metaanalysis	323
5	Mood disorder	517	15	Activation	317
6	Prefrontal cortex	496	16	Abnormality	312
7	Brain	455	17	Major depressive disorder	301
8	Major depression	440	18	Mood	263
9	Schizophrenia	419	19	Anterior cingulate cortex	233
10	MRI	386	20	Magnetic resonance imaging	221

Discovering abnormal brain structure and network

In vivo neuroimaging of neural networks that putatively regulate normal emotions have shown that they are implicated in the pathogenesis of mood disorders [12]. Therefore, functional and structural brain pathology may contribute to mood disorders [46, 47]. Reduced gray matter volume has been reported in the posterior cingulate cortex and superior temporal gyrus in bipolar disorder [48], while white matter abnormalities have been associated with major depression [49]. Severe depression cases exhibit ventricular enlargement, sulcal widening, and reduced frontal lobe, hippocampus and caudate nucleus volumes [50]. Advances in brain imaging of mood disorders have been mainly due to studying regional brain abnormalities, and more recently, studying whole brain connectome. Various MRI strategies, including 'functional' MRI, which detects changes in blood flow to a specific area of the brain, blood-oxygen-level-dependent imaging (BOLD) fMRI, which examines changes in oxygenated or deoxygenated blood, and resting state fMRI have significantly improved our knowledge of neuronal activity. Mood disorder patients exhibit morphological abnormalities or morphometry in various visceromotor network structures [51]. Young MDD reported significant reduction in DRN-cingulate cortex connectivity relative to healthy controls and a correlation between DRN amygdala/hippocampus complex connectivity and depressive symptom severity [42]. Wayne C [46] proposed a neural model in which dysfunctions of MPFC and the circuits connecting it to other cortical and limbic structures account for mood disorder associated neural mechanisms.

Sex differences

Biological differences between sexes affect emotions and social behavior [52]. Lifetime depression and anxiety disorder rates are twice higher in women than men [53, 54]. Gender impacts mood and anxiety disorders and may, therefore, offer some insights into the mechanistic basis of affective disturbances in men and women [55–57]. Besides, women's moods are significantly affected by changes in menstrual cycle. Depression, anxiety and irritability are the three most studied symptoms of PMDD in women of childbearing age [58]. During the perinatal period, mood disturbance are commonly reported by women [59]. Depression is a common complication of pregnancy and the postpartum period [60]. Moreover, menopausal transition is correlated with mood changes ranging from distress to minor depression to major depressive disorders in women [61].The role of reproductive steroids in mood regulation among women may become the most potential research direction [62]. Given that sex differences affect various aspects of the brain, including its structure, function, and stress responses, studies should aim at establishing gender-associated differences that have an effect on mood disorders [63, 64].

Effect of treatment measures on brain activity

Effective therapies for emotional disorders are urgently needed. Although various pharmacological and non-pharmacological therapeutic approaches, including electroconvulsive therapy, cognitive behavioral therapy, ketogenic diets [65], circadian treatment [66], bright-light therapy [67] and drug naïve (ketamine, lithium salts) [68, 69] are available, their efficacies are widely varied between individuals.

Evidence-based medicine with meta-analysis

Meta-analysis may help discern important findings across disparate studies, thereby, providing actionable information to clinicians [70, 71]. For instance, multiple antidepressants are available for MDD, and their prescription should be informed by the best available data. A meta-analysis by Andrea Cipriani [72] on the relative efficacy and tolerability of 21 antidepressants used to treat major depressive disorders found that all antidepressants were more efficacious than placebo in adults. A meta-analysis study also showed that the relationship between creativity and mood disorders

Keywords	Year	Strength	Begin	End	1999 - 2020
rumination	1999	4.6713	2014	2020	
nucleus accumben	1999	3.2264	2014	2020	
cortical thickness	1999	12.5126	2014	2020	
network	1999	14.3488	2014	2020	
comorbidity	1999	3.821	2014	2020	
social cognition	1999	4.3748	2015	2020	
ventral striatum	1999	5.9234	2015	2020	
brain network	1999	7.4338	2015	2020	
resting-state fmri	1999	9.1527	2015	2020	
functionalconnectivity	1999	5.3189	2015	2020	
neural basis	1999	3.226	2015	2020	
cortisol	1999	4.4794	2016	2020	
diagnosis	1999	4.5996	2016	2020	
state functional connectivity	1999	8.4492	2016	2020	
resting state	1999	6.0116	2016	2020	
default mode network	1999	17.7588	2016	2020	
empathy	1999	3.9855	2016	2020	
connectivity	1999	7.794	2016	2020	
impulsivity	1999	4.7199	2016	2020	
sex difference	1999	3.4206	2017	2020	
ptsd	1999	5.8121	2017	2020	
cognitive behavioral therapy	1999	5.0917	2017	2020	
chronic pain	1999	4.4911	2017	2020	
brain structure	1999	3.8852	2017	2020	
symptom	1999	5.2983	2017	2020	
resting state fmri	1999	7.2786	2017	2020	
emotion regulation	1999	11.5739	2017	2020	
electroconvulsive therapy	1999	3.514	2017	2020	
drug naive	1999	3.1432	2017	2020	
irritability	1999	3.1669	2018	2020	
scale	1999	10.2641	2018	2020	
segmentation	1999	5.2156	2018	2020	
stimulation	1999	3.9361	2018	2020	
sleep	1999	4.2231	2018	2020	
episodic memory	1999	3.3641	2018	2020	
mind	1999	3.6253	2018	2020	
trauma	1999	5.8078	2018	2020	
prevalence	1999	7.9204	2018	2020	
salience network	1999	6.1287	2018	2020	
metaanalysis	1999	11.8518	2018	2020	

Fig.10 Top 40 Keywords with Citation Bursts from 2016 to 2020

varied according to the research methodology used [73]. Low doses of partial dopamine agonist therapies represent a relatively safe and effective alternative therapies [74]. Additionally, a meta-analysis showed that lithium, which is commonly used to manage mood disorders, may elevate the risk of low urine concentrations, hypothyroidism, hyperparathyroidism, and weight gain [75].

Conclusions

We performed a bibliometric analysis of publications involving the use of MRI in mood disorder studies over the last 2 decades. Within this period, the number of such publications rose rapidly. The US, England, and Canada have high publication rates and centrality in this area. Additionally, research collaborations on this topic are very active. Our findings reveal Soares JC as the most prolific author, while the US emerged as the global leader in research investment. Mounting evidence shows that MRI is an effective tool for elucidating neuronal activity. The US department of human health services is the leading funding agency on this topic. We also found that depression, bipolar disorder and schizophrenia are the major focus areas when evaluating major brain regions, including the amygdala, prefrontal cortex and anterior cingulate cortex. Our findings indicate that in future, studies will likely focus on brain structure and network, sex differences, brain changes upon treatment and meta-analyses.

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Author contributions GM and SH conceived the study and wrote the manuscript. GM, SH and CX collected and analyzed the data, contributed materials/analysis tools, prepared figures and/or tables and read the final draft. GD and QM contributed to study conception and its coordination. All authors read and approved the final manuscript.

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Data availability The extracted data and statistical syntax are available from the first author upon reasonable request.

Declarations

Conflicts of interest The authors declare no conflict of interest.

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