NeuroImage 139 (2016) 149–156

Contents lists available at ScienceDirect

NeuroImage

journal homepage: www.elsevier.com/locate/ynimg

The 100 most-cited articles in neuroimaging: A bibliometric analysis

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ARTICLE INFO

Article history:
Received 3 April 2016
Revised 16 June 2016
Accepted 17 June 2016
Available online 18 June 2016

Keywords:
Bibliometric analysis
Citation
Citation classics
Neuroimaging

ABSTRACT

The purpose of our study was to identify and characterize the 100 most-cited articles in neuroimaging. Based on the database of Journal Citation Reports, we selected 669 journals that were considered as potential outlets for neuroimaging articles. The Web of Science search tools were used to identify the 100 most-cited articles relevant to neuroimaging within the selected journals. The following information was recorded for each article: publication year, journal, category and impact factor of journal, number of citations, number of annual citations, authorship, department, institution, country, article type, imaging technique used, and topic. The 100 most-cited articles in neuroimaging were published between 1980 and 2012, with 1995–2004 producing 69 articles. Citations ranged from 4384 to 673 and annual citations ranged from 313.1 to 24.9. The majority of articles were published in radiology/imaging journals ($n = 75$), originated in the United States ($n = 58$), were original articles ($n = 63$), used MRI as imaging modality ($n = 85$), and dealt with imaging technique ($n = 45$). The Oxford Centre for Functional Magnetic Resonance Imaging of the Brain at John Radcliffe Hospital ($n = 10$) was the leading institutions and Karl J. Friston ($n = 11$) was the most prolific author. Our study presents a detailed list and an analysis of the 100 most-cited articles in the field of neuroimaging, which provides an insight into historical developments and allows for recognition of the important advances in this field.

Introduction

Neuroimaging is a branch of medical imaging that focuses on the central nervous system. The field of neuroimaging has rapidly grown and evolved through advancements of imaging technologies over the past decades (Hoeffner et al., 2012). This development could be indicated by a large number of articles published in the scientific journals.

A citation is the acknowledgement that one scientific article (the citing article) uses another (the cited article) as a reference. The number of citations is not only an indicator of the impact of an article on the scientific community but also form the basis of journal impact factor (IF) generation (Moed, 2009; Eyre-Walker and Stoletzki, 2013). Therefore, reviewing the most-cited articles (so-called "citation classics") can provide interesting information about scientific progress and research trends in a specific field of discipline.

A number of studies have reported the most-cited articles in various clinical disciplines, such as general surgery (Paladugu et al., 2002), anesthesiology (Baltussen and Kindler, 2004), neurosurgery (Ponce and Lozano, 2010), obstetrics and gynecology (Brandt et al., 2010), orthopedics (Kelly et al., 2010), and rehabilitation (Shadgan et al., 2010). As the first study in the field of radiology, Chew listed the 50 most frequently cited papers published in the *American Journal of Roentgenology* in 1988 (Chew, 1988). Recently, several authors published bibliometric analyses of the 100 most-cited articles in the field of radiology (Yoon et al., 2013; Brinjikji et al., 2013; Pagni et al., 2014) or radiological subspecialties (Crockett et al., 2015; Dolan et al., 2015). To our knowledge, however there has been no bibliometric analysis of the most-cited articles in the field of neuroimaging.

The purpose of present study was to identify and analyze the 100 most-cited articles in the field of neuroimaging.

Materials and methods

Our study was a bibliometric analysis that did not involve human subjects and was exempted from the need for an institutional review board approval.

Two reviewers (H.J.K. and E.S.K., board-certified neuroradiologists with 5 and 10 years of experience, respectively) independently conducted journal selection, article identification, and analyses of articles. Any disagreements between reviewers were resolved by a third reviewer (D.Y.Y., a board-certified neuroradiologist with 20 years' experience).

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http://dx.doi.org/10.1016/j.neuroimage.2016.06.029
1053-8119/

Table 1
The 100 most-cited neuroimaging articles ranked in order of the number of citations received.

Ranking	Article	No. of citations	No. of citations/year (ranking)
1	Tzourio-Mazoyer N, Landeau B, Papathanassiou D, Crivello F, Etard O, Delcroix N, Mazoyer B, Joliot M. Automated anatomical labeling of activations in SPM using a macroscopic anatomical parcellation of the MNI MRI single-subject brain. *Neuroimage* 2002;15(1):273–89.	4384	313.1 (1)
2	Ashburner J, Friston KJ. Voxel-based morphometry—the methods. *Neuroimage* 2000;11(6 Pt 1):805–21.	3973	248.3 (2)
3	Smith SM. Fast robust automated brain extraction. *Hum Brain Mapp* 2002;17(3):143–55.	3201	243.1 (4)
4	Biswal B, Yetkin FZ, Haughton VM, Hyde JS. Functional connectivity in the motor cortex of resting human brain using echo-planar MRI. *Magn Reson Med* 1995;34(4):537–41.	2928	144.6 (16)
5	Smith SM, Jenkinson M, Woolrich MW, Beckmann CF, Behrens TE, Johansen-Berg H, Bannister PR, De Luca M, Drobnjak I, Flitney DE, Niazy RK, Saunders J, Vickers J, Zhang Y, De Stefano N, Brady JM, Matthews PM. Advances in functional and structural MR image analysis and implementation as FSL. *Neuroimage* 2004;23 Suppl 1:S208–19.	2763	243.8 (3)
6	Jenkinson M, Bannister P, Brady M, Smith S. Improved optimization for the robust and accurate linear registration and motion correction of brain images. *Neuroimage* 2002;17(2):825–41.	2627	198.3 (8)
7	Genovese CR, Lazar NA, Nichols T. Thresholding of statistical maps in functional neuroimaging using the false discovery rate. *Neuroimage* 2002;15(4):870–8.	2623	190.8 (9)
8	Dale AM, Fischl B, Sereno MI. Cortical surface-based analysis. I. Segmentation and surface reconstruction. *Neuroimage* 1999;9(2):179–94.	2543	150.3 (14)
9	Good CD, Johnsrude IS, Ashburner J, Henson RN, Friston KJ, Frackowiak RS. A voxel-based morphometric study of ageing in 465 normal adult human brains. *Neuroimage* 2001;14(1 Pt 1):21–36.	2481	171.1 (11)
10	Maldjian JA, Laurienti PJ, Kraft RA, Burdette JH. An automated method for neuroanatomic and cytoarchitectonic atlas-based interrogation of fMRI data sets. *Neuroimage* 2003;19(3):1233–9.	2336	186.9 (10)
11	Jenkinson M, Smith S. A global optimisation method for robust affine registration of brain images. *Med Image Anal* 2001;5(2):143–56.	2192	151.2 (13)
12	Giedd JN, Blumenthal J, Jeffries NO, Castellanos FX, Liu H, Zijdenbos A, Paus T, Evans AC, Rapoport JL. Brain development during childhood and adolescence: a longitudinal MRI study. *Nat Neurosci* 1999;2(10):861–3.	2141	131.8 (21)
13	Cabeza R, Nyberg L. Imaging cognition II: An empirical review of 275 PET and fMRI studies. *J Cogn Neurosci* 2000;12(1):1–47.	2131	133.2 (20)
14	Fischl B, Sereno MI, Dale AM. Cortical surface-based analysis. II: Inflation, flattening, and a surface-based coordinate system. *Neuroimage* 1999;9(2):195–207.	2061	121.8 (23)
15	Fox MD, Raichle ME. Spontaneous fluctuations in brain activity observed with functional magnetic resonance imaging. *Nat Rev Neurosci* 2007;8(9):700–11.	2004	240.5 (5)
16	Zhang Y, Brady M, Smith S. Segmentation of brain MR images through a hidden Markov random field model and the expectation-maximization algorithm. *IEEE Trans Med Imaging* 2001;20(1):45–57.	1939	129.3 (22)
17	Klunk WE, Engler H, Nordberg A, Wang Y, Blomqvist G, Holt DP, Bergström M, Savitcheva I, Huang GF, Estrada S, Ausén B, Debnath ML, Barletta J, Price JC, Sandell J, Lopresti BJ, Wall A, Koivisto P, Antoni G, Mathis CA, Långström B. Imaging brain amyloid in Alzheimer's disease with Pittsburgh Compound-B. *Ann Neurol* 2004;55(3):306–19.	1938	163.8 (12)
18[a]	Nichols TE, Holmes AP. Nonparametric permutation tests for functional neuroimaging: a primer with examples. *Hum Brain Mapp* 2002;15(1):1–25.	1924	137.4 (18)
18[a]	Smith SM, Jenkinson M, Johansen-Berg H, Rueckert D, Nichols TE, Mackay CE, Watkins KE, Ciccarelli O, Cader MZ, Matthews PM, Behrens TE. Tract-based spatial statistics: voxelwise analysis of multi-subject diffusion data. *Neuroimage* 2006;31(4):1487–505.	1924	202.5 (7)
20	Aaslid R, Markwalder TM, Nornes H. Noninvasive transcranial Doppler ultrasound recording of flow velocity in basal cerebral arteries. *J Neurosurg* 1982;57(6):769–74.	1835	55.5 (63)
21	Beaulieu C. The basis of anisotropic water diffusion in the nervous system - a technical review. *NMR Biomed* 2002;15(7–8):435–55.	1802	137.3 (19)
22	Mori S, Crain BJ, Chacko VP, van Zijl PC. Three-dimensional tracking of axonal projections in the brain by magnetic resonance imaging. *Ann Neurol* 1999;45(2):265–9.	1797	106.2 (29)
23	Lancaster JL, Woldorff MG, Parsons LM, Liotti M, Freitas CS, Rainey L, Kochunov PV, Nickerson D, Mikiten SA, Fox PT. Automated Talairach atlas labels for functional brain mapping. *Hum Brain Mapp* 2000;10(3):120–31.	1786	111.6 (26)
24	Provencher SW. Estimation of metabolite concentrations from localized in vivo proton NMR spectra. *Magn Reson Med* 1993;30(6):672–9.	1752	79.3 (38)
25	Fisher CM, Kistler JP, Davis JM. Relation of cerebral vasospasm to subarachnoid hemorrhage visualized by computerized tomographic scanning. *Neurosurgery* 1980;6(1):1–9.	1746	48.5 (74)
26	Le Bihan D, Breton E, Lallemand D, Grenier P, Cabanis E, Laval-Jeantet M. MR imaging of intravoxel incoherent motions: application to diffusion and perfusion in neurologic disorders. *Radiology* 1986;161(2):401–7.	1666	57.1 (61)
27	Worsley KJ, Marrett S, Neelin P, Vandal AC, Friston KJ, Evans AC. A unified statistical approach for determining significant signals in images of cerebral activation. *Hum Brain Mapp* 1996;4(1):58–73.	1665	82.9 (35)
28	Phan KL, Wager T, Taylor SF, Liberzon I. Functional neuroanatomy of emotion: a meta-analysis of emotion activation studies in PET and fMRI. *Neuroimage* 2002;16(2):331–48.	1637	116.9 (25)
29	Pierpaoli C, Jezzard P, Basser PJ, Barnett A, Di Chiro G. Diffusion tensor MR imaging of the human brain. *Radiology* 1996;201(3):637–48.	1507	79.0 (39)
30	Eickhoff SB, Stephan KE, Mohlberg H, Grefkes C, Fink GR, Amunts K, Zilles K. A new SPM toolbox for combining probabilistic cytoarchitectonic maps and functional imaging data. *Neuroimage* 2005;25(4):1325–35.	1486	139.3 (17)
31	Friston KJ, Harrison L, Penny W. Dynamic causal modelling. *Neuroimage* 2003;19(4):1273–302.	1466	118.1 (24)
32	Basser PJ, Pajevic S, Pierpaoli C, Duda J, Aldroubi A. In vivo fiber tractography using DT-MRI data. *Magn Reson Med* 2000;44(4):625–32.	1457	95.5 (30)
33	Friston KJ, Holmes AP, Poline JB, Grasby PJ, Williams SC, Frackowiak RS, Turner R. Analysis of fMRI time-series revisited. *Neuroimage* 1995;2(1):45–53.	1450	69.6 (48)
34	Desikan RS, Ségonne F, Fischl B, Quinn BT, Dickerson BC, Blacker D, Buckner RL, Dale AM, Maguire RP, Hyman BT, Albert MS, Killiany RJ. An automated labeling system for subdividing the human cerebral cortex on MRI scans into gyral based regions of interest. *Neuroimage* 2006;31(3):968–80.	1409	148.3 (15)
35	Boynton GM, Engel SA, Glover GH, Heeger DJ. Linear systems analysis of functional magnetic resonance imaging in human V1. *J Neurosci* 1996;16(13):4207–21.	1392	71.4 (45)
36	Worsley KJ, Friston KJ. Analysis of fMRI time-series revisited—again. *Neuroimage* 1995;2(3):173–81.	1361	66.9 (50)
37	Bandettini PA, Jesmanowicz A, Wong EC, Hyde JS. Processing strategies for time-course data sets in functional MRI of the human brain. *Magn Reson Med* 1993;30(2):161–73.	1311	58.5 (59)
38	Friston, KJ; Buechel, C; Fink, GR; Morris, J; Rolls, E; Dolan, RJ. Psychophysiological and modulatory interactions in neuroimaging. *Neuroimage*1997;6(3):218–29.	1305	71.5 (44)
39	Ogawa S, Lee TM, Nayak AS, Glynn P. Oxygenation-sensitive contrast in magnetic resonance image of rodent brain at high magnetic fields. *Magn Reson Med* 1990;14(1):68–78.	1298	50.4 (70)
40	Le Bihan D, Mangin JF, Poupon C, Clark CA, Pappata S, Molko N, Chabriat H. Diffusion tensor imaging: concepts and applications. *J Magn Reson Imaging* 2001;13(4):534–46.	1232	83.5 (34)