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"Word Blindness" (Dyslexia) : A Bibliometric Analysis of Global Research in Last Fifty Years

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ABSTRACT

Dyslexia (commonly known as word blindness) is a cognitive (learning) disorder characterised by an impaired ability to comprehend written and printed words or phrases despite of intact vision. A quantitative literature analysis was carried out on learning disorder - dyslexia from 1967 to 2016 (50 Year) for assessing the global research trends. The emphasis has been given to analyse the research progress in dyslexia using bibliometric methods. This literature-based study was carried out with the documents retrieved from the Scopus. There were 13455 articles on Dyslexia in SCOPUS, distributed in nine document types and twenty eight languages. These literature were grown at 6 per cent annually. Of ninety eight countries, USA shared highest contribution. India ranked 20th in terms of total publication. The most of the research areas are centered towards psychology, learning ability and linguistics.

Keywords: Dyslexia; Alexia; Bibliometric analysis; Research impact.

1. INTRODUCTION

Historically, the term "Word Blindness" (Dyslexia) was used for the person having normal intelligence but unable to read the written word 1,2. At later stage, it was argued that the problem of Dyslexia is associated with visual perception and visual memory[3]. As the research progressed, it was theorised as Dyslexia is a neuro-cognitive disorder which is characterised by difficulty in acquiring reading skills despite of adequate intelligence and sufficient reading opportunities[4,5]. There has been different theory proposed on development of dyslexia in general population. The strong theoretical opinion about dyslexia appeared as genetic basis[6]. The etiological studies concluded that more than ten per cent school children are suffering with dyslexic due to poor identification of words[7,8]. More theories appeared which has strong co-relation between cause and effect includes phonological theory[9,10], visual processing[11,12], and Neuropsychological deficits[13]. Continuous research and development is taking place to improve the diagnostic technology and treatment methods to cure the diseases. The assessment and progress of research is continuously being monitored through case studies and various qualitative and quantitative research methods.

Bibliometric methods are increasingly being used as an analytical tool to monitor the progress and impact of research and performance assessment in a given field of study[14,15]. The dyslexia cases are more concerned with the psychology (especially child psychology) and education. A huge demand has been created for the people who are able to understand the prognosis and diagnosis of the disease[16]. With an increasing academic requirement, there is a need to assess the multifaceted research progress in dyslexia. There has been some bibliometric studies reported in speech, language and hearing sciences, public health[17], ophthalmology[18], ophthalmic epidemiology and prevention[19], and otology[20]. None of these studies addresses the research progress associated with dyslexia. The purpose of the study is to analyses the growth pattern of literature and research impact in terms of annual growth, most productive country, institution and journals, most frequently cited articles, multidimensional research growth using keyword analysis, impact of research in terms of citation[21] and *h*-Index[22,23].

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2. METHODOLOGY

The bibliographic literature on dyslexia were retrieved from the Scopus database from 1967 to 2016. Scopus is becoming one of the reliable sources of biographic indexing and abstracting database which is now being used for various benchmarking activities such as Times Higher Ranking, QS Ranking, NIRF Ranking etc. along with literature and bibliometric analysis.

There are two major condition of dyslexia – developmental and acquired. The literature on this cognitive disorder was retrieved by using MeSH terms describing dyslexia. The search criteria used for retrieving data is as follows.

(TITLE-ABS-KEY (dyslexia) OR TITLE-ABS-KEY (developmental AND dyslexia) OR TITLE-ABS-KEY (

dyslexias) OR TITLE-ABS-KEY (acquired AND dyslexia) OR TITLE-ABS-KEY (alexia)) AND PUBYEAR > 1966 AND PUBYEAR < 2017

The search field was chosen as Title, Abstract and Author keywords, which covers almost all central theme of a research paper. The time period was kept from 1967 till 2016 (50 year). The term dyslexia was included in the MeSH list in 1966.

3. RESULTS AND DISCUSSION

3.1 Document Types and Language of Publication

The 13,455 dyslexia publication were published in nine document type during the 50-year study period. A total of 12,344 document were published in the 2127 journals was the most frequently published document types. It was followed by review (1164; 8.65 %) and conference proceeding (661; 4.91 %), Book chapters (339; 2.52 %), letter (278; 2.07 %), Editorial (241; 1.79 %), Note (192; 1.43 %). Other document types were less than one percent share. The 13,455 document on dyslexia were published in 28 language where, 97.67 per cent of articles were published in five major language. English was most common mode of communication with 89.03 per cent, followed by German (3.51 %), French (3 %), Spanish (1.12 %) and Japanese (1.01 %).

3.2 Publication Growth

There were 13,455 articles on Dyslexia during last fifty years' period. The Dyslexia literature in Scopus has grown at the rate of 6.0 per cent per year. The analysis was carried out in a block period of ten year and it is found that the maximum growth was during the period of 1997-2006 which has witnessed 92.55 per cent growth as compared to the previous decade. Similarly, the total citation counts as well as average citation per paper has been found maximum during this period. The 3,437 article accumulated a total of 1,44,462 citation with an average citation per paper of 42.03 citations. However, 42.43 per cent publications appeared during the period from 2007 to 2016, and 75,481 citation as shown in Table 1. There was a decline in percent growth of publication during the period from 1987 to 1996 which was only 14.86 per cent as compared to publication growth during the period of 1977-86 as shown in Fig. 1. The total citation accumulated by 13,455 articles were 3,42,785 with an average citation per paper of 25.48 citations during fifty-year period.

Table 1. Dyslexia publication growth pattern in ten-year block period

Period	TP	% Share	% Growth Rate	TC	ACPP
1967-76	970	7.21	-	15194	15.66
1977-86	1554	11.55	60.21	39492	25.41
1987-96	1785	13.27	14.86	68156	38.18
1997-06	3437	25.54	92.55	144462	42.03
2007-16	5709	42.43	66.10	75481	13.22
Total	13455		6.0%	342785	25.48

TP-Total Publications; TC-Total Citations; ACPP-Average Citation Per Paper

3.3 Productive Country in Dyslexia Research

The contribution provided by different countries/territories

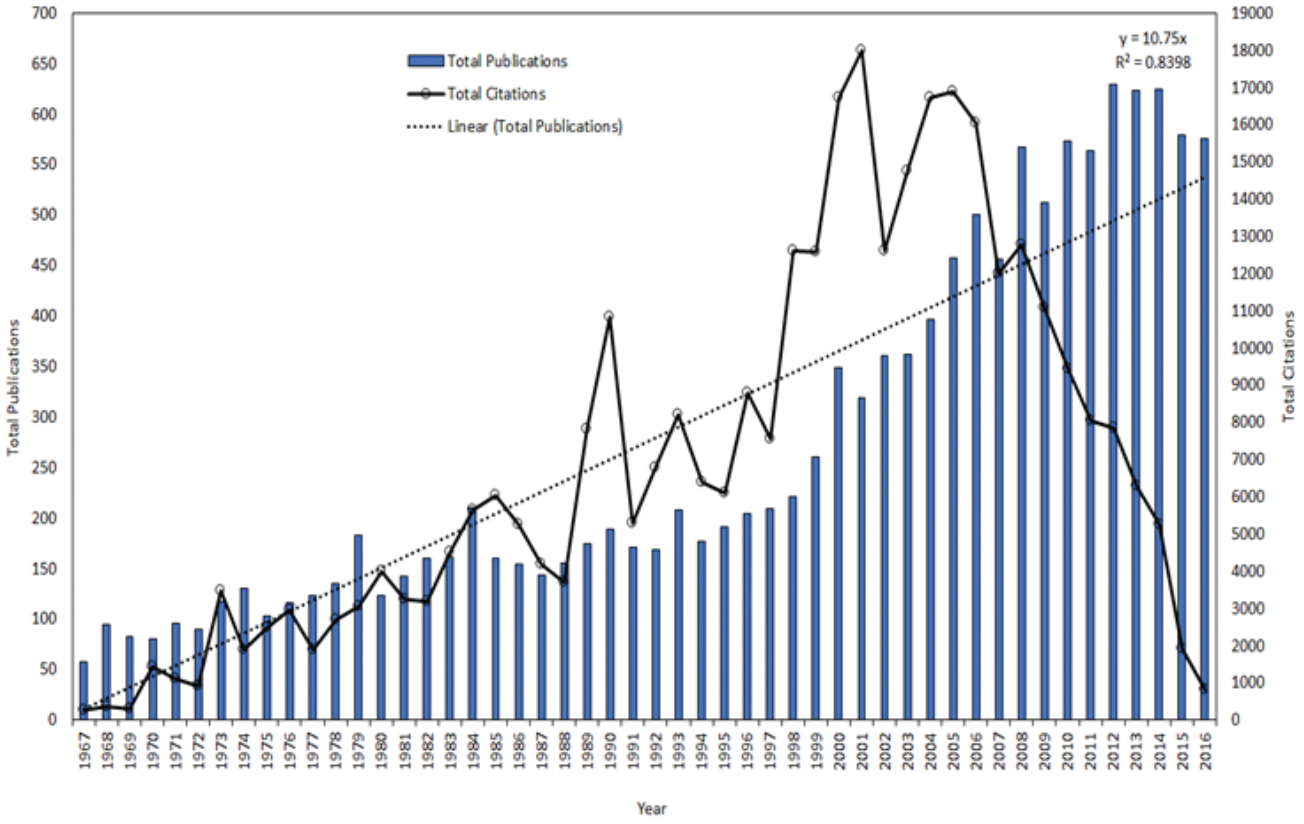


Figure 1. Dyslexia publication growth, 1967-2016.

Table 2. Most productive countries with more than 100 article on Dyslexia

Country	TP	% Share	TPR	SCP	SCPR	ICP	ICPR	TC	ACPP	H-Index
United States	3925	29.17	1	2836	1	878	1	150580	38.36	168
United Kingdom	2347	17.44	2	1336	2	746	2	81528	34.74	133
Germany	753	5.60	3	362	4	357	3	13551	18	58
Canada	650	4.83	4	323	6	279	4	24232	37.28	74
France	620	4.61	5	390	3	230	7	19714	31.8	63
Italy	571	4.24	6	350	5	221	9	12577	22.03	59
Australia	484	3.60	7	249	7	234	6	15417	31.85	60
Netherlands	373	2.77	8	137	10	236	5	8044	21.57	48
Israel	302	2.24	9	177	9	125	14	6421	21.26	41
Finland	278	2.07	10	48	18	230	8	10473	37.67	59
Japan	274	2.04	11	185	8	87	18	2857	10.43	26
Spain	271	2.01	12	135	11	136	13	3128	11.54	25
Sweden	236	1.75	13	90	14	146	11	6779	28.72	38
Norway	192	1.43	14	84	15	108	16	4056	21.13	35
Belgium	190	1.41	15	46	19	144	12	4287	22.56	37
China	167	1.24	16	51	17	116	15	2011	12.04	21
Switzerland	160	1.19	17	3	23	157	10	2805	17.53	29
Brazil	137	1.02	18	96	13	41	22	870	6.35	14
Hong Kong	121	0.90	19	43	20	78	19	2429	20.07	25
India	120	0.89	20	101	12	19	23	863	7.19	16
Austria	118	0.88	21	10	22	108	17	4227	35.82	36
Greece	116	0.86	22	71	16	45	21	1629	14.04	20
New Zealand	115	0.85	23	12	21	72	20	3535	30.74	30
Sub Total	12520	93.05								

TP-Total Publication, TPR-Rank of Total Publication, SCP-Single Country Publication, SCPR-Single Country Publication Rank, ICP-International Collaborated Paper, ICPR-International Collaborated Paper Rank, TC-Total Citation, ACPP-Average Citation Per Paper.

was estimated by focusing the location of the affiliation country of at least one author in the published papers. Not all articles were included in the analysis as 2,043 (15.18 %) articles were without author address information in the Scopus database.

The 11,412 article with author address information, published from 98 country during 1967 to 2016. The top 23 country/territory with more than 100 article were ranked according to five indicator which includes total articles (TA), share of publication and rank, single country article (SCA) and rank, internationally collaborated articles (ICA) and rank, total citations (TC), average citation per paper (ACPP), and *h*-index as shown in Table 2. These countries shared 93.05 per cent of global publication. Out of these, fourteen country are from European region. Some of the study reported that due to difficulty is speaking English language by student in non-native English speaker may developed dyslexia[24-26]. Fourteen country had only single country articles (SCA), whereas, ten country had no internationally collaborated articles (ICA). Twenty-nine country contributed only one or two SCA, while nine country contributed only one or two ICA. All the top six country with the most publications on dyslexia were occupied by the seven major industrial countries of the world (G7 country): United States, United Kingdom, Germany, Canada, France, and Italy. These were ranked from 1st to 6th, while Japan was at 11th position. Similar results were also reported on research productivity in Photosynthesis[27]. The USA published the most articles (29.17 %), followed by UK (17.44 %) and Germany (5.60 %). The USA also published most of the SCA (2,836 article) followed by the UK (1,336 article) and France (390 article). The USA also published most of the ICA (878 article), followed by the UK (746 article) and Germany (357 article).

Figure 2 shows the comparison of literature output from G7 countries during the period of study. USA top the rank in terms of total citation count of 150580 citations with an average citation per paper of 38.36 citation followed by the UK with 81528 citation with an ACPP of 34.74 citation and Canada with a total citation of 24232 citation with an ACPP of 37.28 citations. However, Finland ranked second in terms of average citation per paper of 37.67 citation for its 278 article.

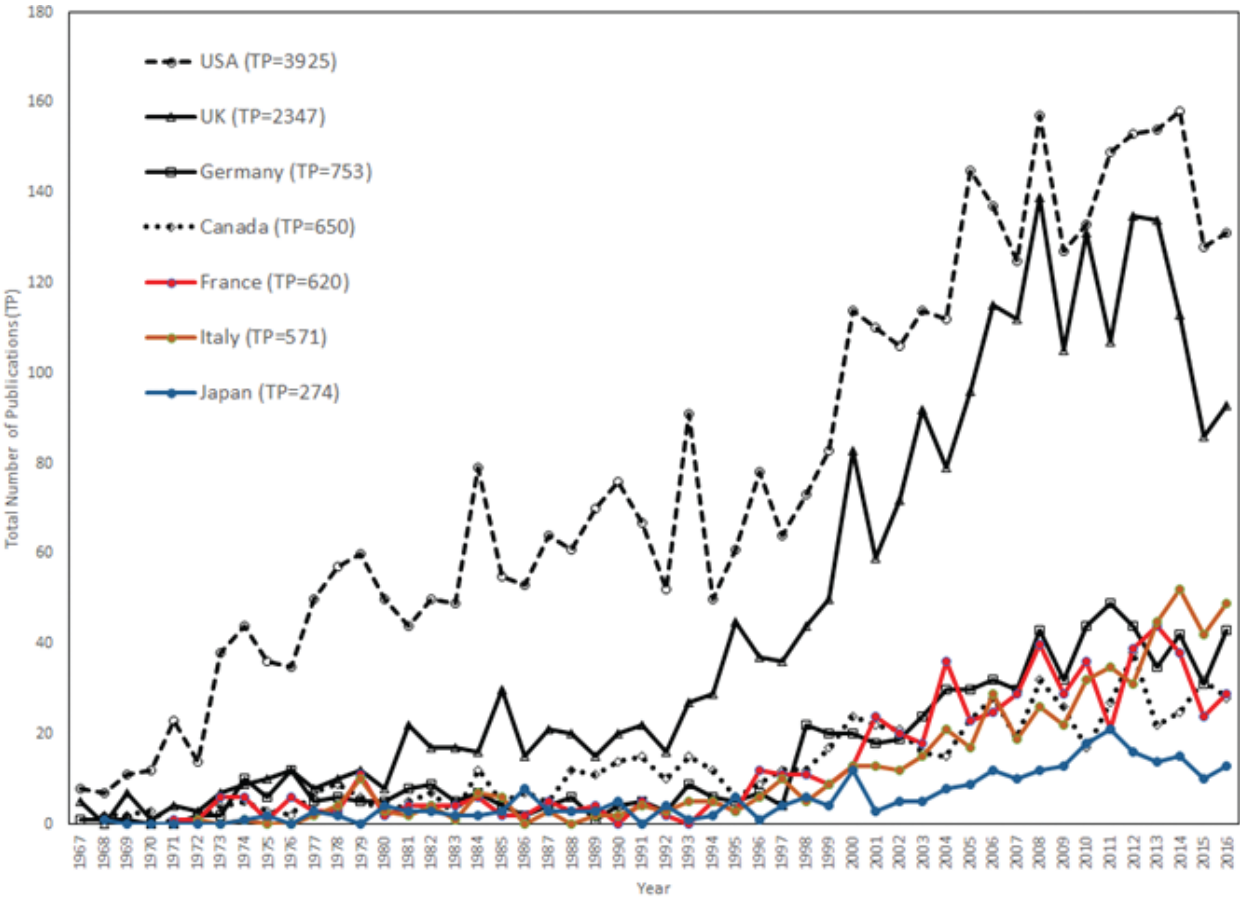


Figure 2. Comparison of growth of articles on Dyslexia published by G7 countries.

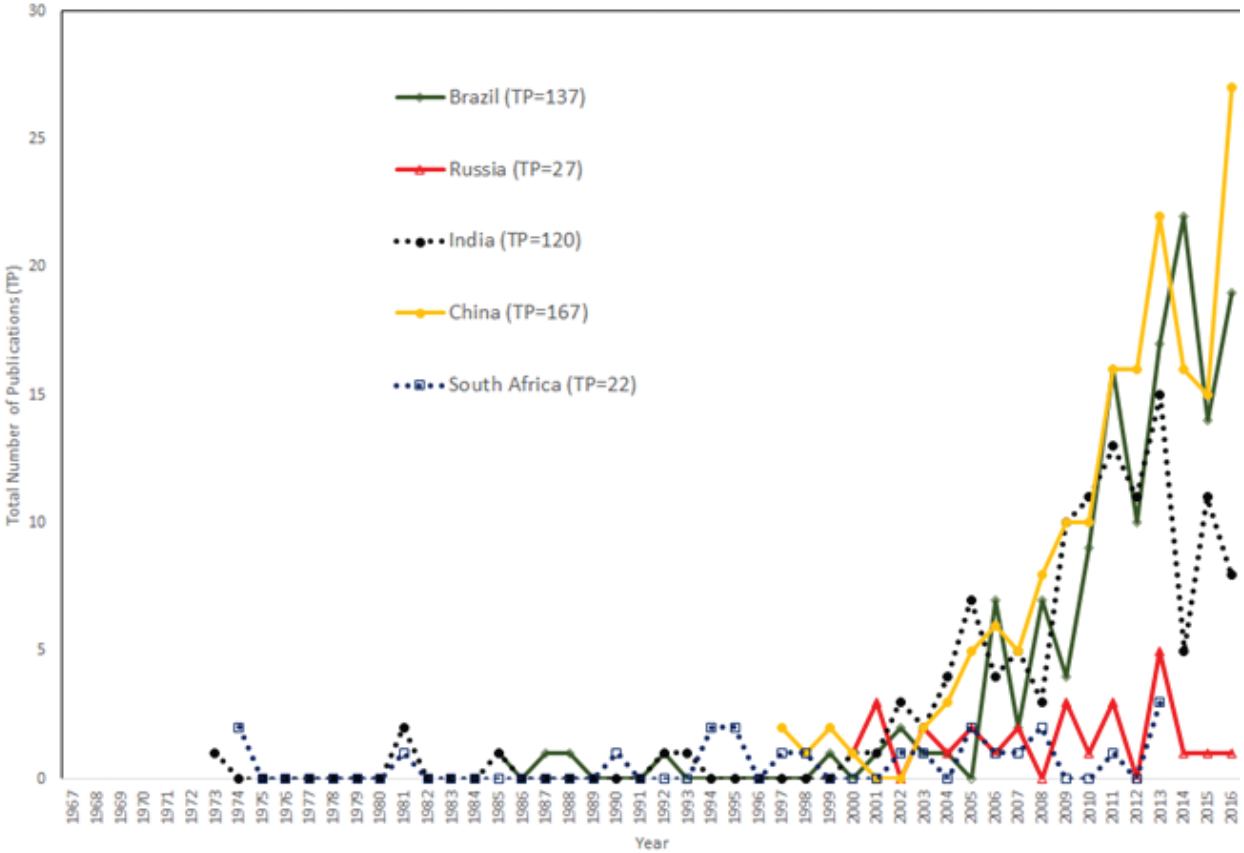


Figure 3. Dyslexia research publication growth by BRICS countries.

Top three country, on the qualitative parameter *h*-Index, were USA (*h*-Index = 168), the UK (*h*-Index = 133) and Canada (*h*-Index = 74).

The contribution from BRICS nation, only China, Brazil and India made their place among the most productive countries in Dyslexia research. China ranked 1st with 167 article, followed by Brazil (137 articles) and India (120 article). Whereas, Russia had 27 article and South Africa had published 22 article. Russian papers started appearing only after the year 2000. China has shown rapid growth of publication with 2 article in 1997 to 27 article in 2016 as shown in Fig. 3.

3.4 Productive Institutions

The Table 3 presents the contribution of different institutions with more than 100 article on dyslexia. Of these top sixteen institution which are ranked by total articles, five are from UK, four are in the USA, two each from France and Finland, whereas Canada and Italy each have one institution. University of Oxford has maximum number of articles (2.21 %) followed by University College of London (2.17 %) and Harvard Medical School, USA (1.34 %). On parameter of citation impact, University College of London, UK has accumulated most number of citations (17,788 citation) with an ACPP of 60.92 citation, followed by University of Oxford UK (14,778 citation) with an ACPP of 49.76 citation and Harvard Medical School USA (11,858 citation) with an ACPP of 65.88 citation. Harvard Medical School has highest average citation per paper. Impact in terms of *h*-Index value, University College of London UK has highest value (*h*-index = 69) followed by University of Oxford (*h*-Index = 67) and Harvard Medical School (*h*-Index = 50).

3.5 Productive Journals with Most Articles on Dyslexia

There were 12,344 article published in 2,127 different journals. *Journal of Learning Disabilities* (IF_{2016} = 1.494) ranked first with 703 (5.70%) article on dyslexia. *Annals of Dyslexia* (IF_{2016} = 1.609) ranked second with 431 (3.49%) article published on the subject, followed by *Dyslexia* (IF_{2016} = 1.39) with 355 article and *Neuropsychologia* (IF_{2016} = 3.197) with 313 article. Moreover, *Brain* with ninety-one articles had the highest impact factor (10.292). Other journals with a high impact factor were *Nature* (IF_{2016} = 40.137; 20 article), *Lancet* (IF_{2016} = 47.831; 18 article), *Nature Reviews Neuroscience* (IF_{2016} = 28.880; 10 article) and *Nature Neuroscience* (IF_{2016} = 17.839; 9 article). Analysis of impact factor helps potential authors to select journals when writing articles on subject specific research[28,29].

Journal of Learning Disabilities ranked 1st with 20,922 citation (*h*-Index = 73), followed by *Audiology & Speech-Language Pathology* with 12411 citation (*h*-Index = 58) and *Neuroscience* with 11963 citation (*h*-Index = 58). Articles published in '*Annals of Dyslexia*' has been cited 10,495 (*h*-Index = 52), times till December 2017. It is ranked 4th in terms of citation and *h*-index. Journal Impact factor, h-index are the quality parameter for every stockholders[30].

3.6 Characteristics of Highly Cited Articles

Out of 13455 articles published on dyslexia, about 20.80 per cent articles have not cited at all and 8.75 per cent

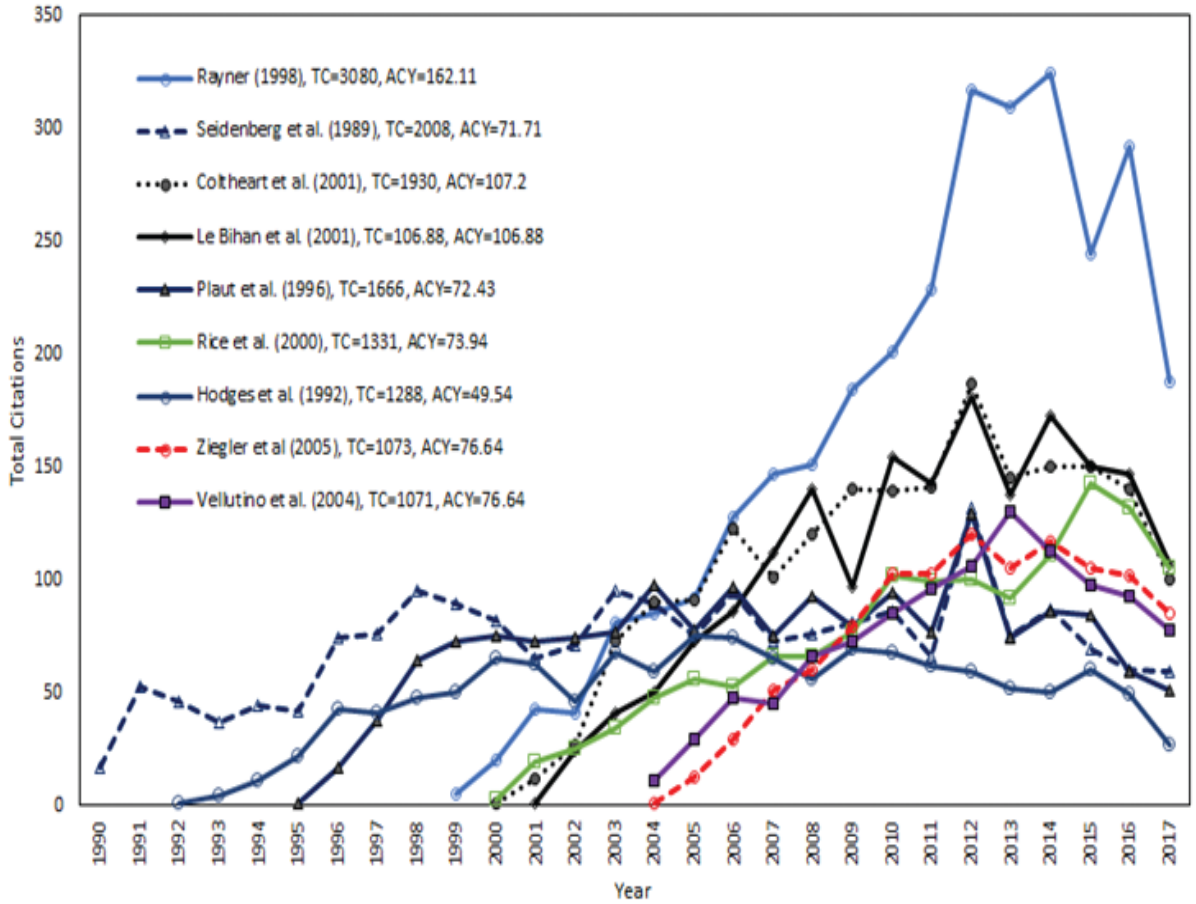
Table 3. Productive institutions with more than 100 article on Dyslexia

Institution	TP	R (%Share)	TC	ACPP	H-Index
University of Oxford, UK	297	1(2.21)	14778	49.76	67
University College of London, UK	292	2(2.17)	17788	60.92	69
Harvard Medical School, USA	180	3(1.34)	11858	65.88	50
CNRS Centre National de la Recherche Scientifique, France	170	4(1.26)	8923	52.49	40
Inserm, France	158	5(1.17)	6158	38.97	34
Jyvaskylan Yliopisto, Finland	137	6(1.02)	5005	36.53	40
University of York, UK	134	7(1.00)	7582	56.58	44
University of Haifa, Israel	129	8(0.96)	2168	16.81	27
VA Medical Center, USA	123	9(0.91)	4564	37.11	38
University of Colorado at Boulder, USA	122	10(0.91)	6992	57.31	42
King's College London, UK	118	11(0.88)	6892	58.41	40
University of Toronto, Canada	116	12(0.86)	6915	59.61	43
Universita degli Studi di Padova, Italy	113	13(0.84)	2984	26.41	32
University of Cambridge, UK	107	14(0.80)	5314	49.66	34
Helsingin Yliopisto, Finland	103	15(0.77)	4267	41.43	43
University of Washington, Seattle, USA	100	16(0.74)	3091	30.91	33
Sub Total	2399	17.83			

TP-Total Publication, TC-Total Citation, ACPP-Average Citation Per Paper

Table 4. Most productive journals in Dyslexia research

Name	Total publications	% Share	IF (2016)	Subject domain
Journal of Learning Disabilities	703	5.70	1.494	Special educational & rehabilitation
Annals of Dyslexia	431	3.49	1.609	Special educational & rehabilitation
Dyslexia	355	2.88	1.390	Special educational & rehabilitation
Neuropsychologia	313	2.54	3.197	Neuroscience
Brain and language	311	2.52	2.439	Audiology & speech-language pathology
Perceptual and Motor Skills	214	1.73	0.626	Psychology
Cortex	183	1.48	4.279	Neurosciences & neurology
Cognitive Neuropsychology	159	1.29	1.146	Psychology
Reading and Writing	139	1.13	1.489	Education & educational research
Journal of Child Psychology and Psychiatry and Allied Disciplines	107	0.87	6.226	Psychology & psychiatry
ANAE	99	0.80	0.133	Neurosciences & neurology
Journal of Experimental Child Psychology	94	0.76	2.602	Psychology
Research in Developmental Disabilities	93	0.75	1.630	Special educational & rehabilitation
Brain	91	0.74	10.292	Neurosciences & neurology
PLoS ONE	89	0.72	2.806	Multidisciplenery science
Neurocase	79	0.64	0.988	Neurosciences & neurology
Journal of Speech, Language, and Hearing Research	76	0.62	1.771	Audiology & speech-language pathology
Brain and Cognition	75	0.61	2.432	Neurosciences & neurology



TC - Total Citation, ACY - Annual Citation Per Year

Figure 4. Most cited articles in Dyslexia.

articles have at least one citation. Eight most frequently cited articles have been cited more than 1,000 times since their initial publication till December 2017 is given in Fig. 4. Three of them were published in '*Psychological Review'* (IF_{2016} = 7.638) and two were published in '*Psychological Bulletin*' (IF_{2016}=16.793). The article 'Eye Movements in Reading and Information Processing: 20 Year of Research' (Ryan 1998) was the most frequently cited articles published in '*Psychological Bulletin*' (IF_{2016}=16.793) with 3080 citations till December 2017 with an average citation per year of 162.11 citation. The other most cited article by Seidenberg, *et al.* (1989) with total citation of 2,008 and average annual citation of 71.71 was less impactful than 2 articles by Coltheart, *et al.* (2001), (TC=1930; ACY=107.2) and Le Bihan, *et al.* (2001) (TC=106.88; ACY=106.88) as shown in Fig. 4.

The citation based research impact measurement is the quite popular technique in a given subject since long time[31,32]. The citation window for these top cited articles states that only one articles Ryner (1998) shows a 'early rise and rapid decline' in citation[33], where as the articles by Seidenberg, *et al.* (1989) and Hodges, *et al.* (1992) shows 'delayed rise and slow decline' and turns out to be more impact full than the article with 'scientific prematurity'[34].

3.7 Author's Keyword and Hot Spot of Research

The author keywords that appeared in the articles from 1967 to 2016 were ranked by frequency of use in the article. The most frequently used keyword for all periods was "dyslexia" as it was also the keyword used as search term. The most frequently used author's keywords during the study period has been classified as disease, visual processing; cognitive disorder, language processing; phonological processing affecting population, environmental factors, diagnostics and treatment methods. Based on the frequency of use the hotspot research areas in dyslexia centred around the keywords focussed on the category of disease includes 'dyslexia' (78.39 %), 'psychological aspects' (11.04 %), 'task performance' (8.49 %), 'Attention deficit' (7.11 %), and 'learning disorder' (6.96 %). The keyword 'Task performance' started appearing after 1981 only. The keyword which depicts the visual and cognitive disorder includes 'reading' (TP = 3,925; 29.12 %), 'learning disorder' (TP = 1,354; 10.06 %), 'cognition' (TP = 1155; 8.58 %). The keywords related to language and phonological processing which were most frequently used includes 'phonetics (TP = 2,058; 15.30 %), 'language' (TP = 1119; 8.32 %), 'language disability' (TP = 937; 6.82 %), 'linguistics' (TP = 795; 6.44 %), 'language development' (TP = 425; 3.16 %). Based on these keywords it can be concluded that the dyslexia is a disease which prevalence in the men having learning disability even though they have normal intelligence quotient[35,36].

4. CONCLUSIONS

The dyslexia is a cognitive disorder which with 10 per cent etiological prevalence among the school children. The study analyses 13,455 articles from Scopus database and it is concluded through bibliometric analysis that these articles appeared in the twelve document type and twenty-eight different language during the period from 1967 to 2016. During these fifty-year period, the literature on dyslexia has grown at 6.0 per cent per year whereas the maximum growth of the literature came during the period of 1997-2006. The 98 country contributed in dyslexia research and all developed countries (G7) were among top productive region. The most of the representation came from European region where there were 14 country out of 22 most productive country. The USA was most productive countries with highest number of paper as well as citation count, but the articles published from Finland ranked second with highest average citation per paper. Among BRICS countries, Brazil, China and India make into most productive countries. University of Oxford has published most number of articles on dyslexia, whereas the articles published from University College of London were most impactful with highest number of citations. '*Journal of Learning Disabilities*' had published most number of articles. The highly cited article were also analysed in term of total citation and there were eight articles with more than one thousand citation during its citation life cycle. The keyword analysis successfully offered interesting insights into the fact that the most of the terms used by author as author's keyword were focussed on education, language, phonetics, learning, cognition and neurological defects and can be considered as hot spot of the research and will continue to grow with more diagnostic and treatment methods in near future.

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