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Examining the Scientific Productivity of Authors in Dyslexia Research: A Study Using Lotka's Law

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Abstract

Dyslexia, or a reading disability, occurs when an individual has significant difficulty with speed and accuracy of word decoding. Comprehension of text and spelling are also affected. The diagnosis of dyslexia involves the use of reading tests, but the continuum of reading performance means that any cut off point is arbitrary. The IQ score does not play a role in the diagnosis of dyslexia. The cognitive difficulties of dyslexics include problems with speech perception, recognizing and manipulating the basic sounds in a language, language memory, and learning the sounds of letters. Dyslexia is a neurological condition with a genetic basis. There are abnormalities in the brains of dyslexic individuals. There are also differences in the electrophysiological and structural characteristics of the brains of dyslexics. Physicians play a particularly important role in recognizing children who are at risk for dyslexia and helping their parents obtain the proper assessment. The fundamental aim of this study was, to analyze the application of Lotka's law to the research publication, in the field of Dyslexia. The data related to Dyslexia were extracted from web of science database, which is a scientific, citation and indexing service, maintained by Clarivate Analytics. A total of 5182 research publications were published by the researchers, in the field of Dyslexia. The study found out that, the Lotka's inverse square law is not fit for this data. The study also analyzed the authorship pattern, Collaborative Index (CI), Degree of Collaboration (DC), Co-authorship Index (CAI), Collaborative Co-efficient (CC), Modified Collaborative Co-efficient (MCC), Lotka's Exponent value, Kolmogorov-Smirnov Test (K-S Test), Relative Growth Rate and Doubling Time.

Keywords: Scientometrics, Collaborative Index (CI), Degree of Collaboration (DC), Co-authorship Index (CAI), Collaborative Co-efficient (CC), Modified Collaborative Co-efficient (MCC), Lotka's Law, Lotka's Exponent value, Kolmogorov-Smirnov Test (K-S Test), Dyslexia.

Introduction

Dyslexia, also known as a reading disability, occurs when an individual has significant difficulty with speed and accuracy of word decoding. Comprehension of text is also affected. Dyslexia is usually accompanied by spelling difficulties. Dyslexia is stable, in that children identified as dyslexic are likely to continue to have reading difficulties throughout adolescence and adulthood (Bruck, 1990; Shaywitz et al, 1999).

Dyslexia is an often-misunderstood, confusing term for reading problems. The word dyslexia is made up of two different parts: *dys* meaning not or difficult, and *lexia* meaning words, reading, or language. So quite literally, dyslexia means difficulty with words (Catts & Kamhi, 2005).

Despite the many confusions and misunderstandings, the term dyslexia is commonly used by medical personnel, researchers, and clinicians. One of the most common misunderstandings about this condition is that dyslexia is a problem of letter or word reversals (*b*/*d*, *was*/*saw*) or of letters, words, or sentences "dancing around" on the page (Rayner et al, 2001).

In fact, writing and reading letters and words backwards are common in the early stages of learning to read and write among average and dyslexic children alike, and the presence of reversals may or may not indicate an underlying reading problem. Ellis (1884) invokes a medical analogy when discussing dyslexia: “First, reading backwardness seems to be a graded thing more like obesity than measles. We cannot in any simple way divide the population into those who are dyslexic and those who are not, so it would seem unlikely that there will exist any symptom or sign that will quantitatively distinguish dyslexics from nondyslexics”.

One of the most complete definitions of dyslexia comes from over 20 years of research:

Dyslexia is a specific learning disability that is neurobiological in origin. It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. These difficulties typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction. (Lyon et al, 2003)

Dyslexia is a specific learning disability in reading that often affects spelling as well. In fact, reading disability is the most widely known and most carefully studied of the learning disabilities, affecting 80% of all those designated as learning disabled.

One aspect of this phonological deficit is that dyslexics show subtle difficulties in speech perception at the level of the phoneme. Studies such as those by Godfrey et al (1981), Manis et al

(1997), Reed (1989) and Werker and Tees (1987) have shown that dyslexics perform poorer than nondyslexics on measures of speech perception. For example, Bertucci et al (2003) found that the perception and production of vowels were particularly difficult for dyslexics. The speech processing difficulties for dyslexics include weak phonological coding for vowel sounds with similar phonetic characteristics.

It is neurobiological in origin, meaning that the problem is located physically in the brain. Dyslexia is not caused by poverty, developmental delay, speech or hearing impairments, or learning a second language, although those conditions may put a child more at risk for developing a reading disability (Snow, Burns, & Griffin, 1998).

Children with dyslexia will often show two obvious difficulties when asked to read text at their grade level. First, they will not be able to read as many of the words in a text by sight as average readers. There will be many words on which they stumble, guess at, or attempt to "sound out." This is the problem with "fluent word recognition" identified in the previous definition.

Second, they will often show decoding difficulties, meaning that their attempts to identify words they do not know will produce many errors. They will not be very accurate in using letter-sound relationships in combination with context to identify unknown words.

These problems in word recognition are due to an underlying deficit in the sound component of language that makes it very difficult for readers to connect letters and sounds in order to decode. People with dyslexia often have trouble comprehending what they read because of the great difficulty they experience in accessing the printed words.

In discussing the arbitrary nature of dyslexia, Shaywitz et al (1992) noted: “Our findings indicate that dyslexia is not an all-or-nothing phenomenon, but like hypertension and obesity, occurs in varying degrees of severity. Although limitations on resources may necessitate the imposition of cutoff points for the provision of services, physicians must recognize that such cutoffs may have no biological validity”.

Dyslexia has a genetic basis, and it is clear that dyslexia tends to run in families. Research has identified several chromosomes that appear to contain the gene or genes for dyslexia, although the exact genetic mechanisms and the inheritance patterns are not known. Familial studies (Pennington, 1991; Pennington & Siegel, 1997; Pennington, 1999; Schulte-Korne et al, 1996; Snowling et al, 2000; Fisher & DeFries, 2002; Regehr & Kaplan, 1988) and discoveries regarding the involvement of specific chromosomes (Fagerheim et al, 1999; Fisher et al, 1999;

Gayán et al, 1999) clearly indicate the genetic basis of dyslexia. Chromosomes 6 and 15 have been implicated. Obviously, environmental factors play a role, but the role of genetics is quite strong (Castles et al, 1999). A study by Castles et al (1999) found that phonological dyslexia (in which individuals have more trouble reading pseudo words) was more heritable than orthographic dyslexia (in which individuals have more trouble reading exception words), although both types showed a significant heritability.

The term 'Scientometrics' is a field which consists of the quantitative methods applied to the study of science as an information process, unlike the behavioural sciences and mainstream philosophy of science, it focuses on texts (documents) as empirical units of analysis. It is a scientific discipline, which performs reproducible measurements of scientific activity, and reveals its objective quantitative regularities. Further, Scientometric methods include statistical and thesaurus methods, and indicators as to the number of citations, terms etc. According to Pouris (1989) 'Scientometrics is for science what econometrics is for economics.' Therefore, it is 'Application of quantitative techniques (systems analysis, mathematical and statistical techniques etc.) to scientific communication (science output, science policy, science administration etc.)' with the objectives of developing science indicators; measuring the impact of science on society; and comparing the output as well as the impact of science at national and international levels.

Review of Literature

Scientometrics has been applied to various fields and trends from journals (Batcha & Ahmad, 2017) ; (Batcha, Jahina, & Ahmad, 2018; Ahmad & Batcha, 2019) and universities (Ahmad & Batcha, 2019) can be elaborated and presented to various stake holders like academicians, information disseminators and professionals that can help in monitoring the development and recognizing trends and changing pattern in the field. For scholars, it provides information on authors who are actively engaged with the subject and the journals where researchers report their findings.

Since the publication of Lotka's paper, numerous authors have attempted to apply Lotka's Law to the literature of various disciplines. Lotka's Law named after Alfred J. Lotka, describes the frequency of publication by authors in any given field (Lotka, 1926). Bradford law of Scattering describes how the literature on a particular subject is scattered or distributed in the journals (Bradford, 1950). Zipf's law named after the linguist George Kingsley Zipf, states that a given a large sample of words used, the frequency of any word is inversely proportional to its rank in the

frequency table (Zipf, 1949)**.** These three laws are the fundamentals of bibliometrics and scientometrics.

While in some studies Lotka's inverse square law holds (e.g., Murphy, 1973) in humanities and (Schorr, 1975) in map librarianship), in others it does not. (Voos, 1974) finds that for the information science literature a new exponent of 3.5 gives the best fit with empirical data. (Schorr, 1974) finds that Lotka's inverse square law is not applicable to the literature of library science and proposes an inverse quadruple law whereby, for each 100 contributors of a single article, about six will contribute two papers, about one will contribute three papers, etc. (Worthen, 1978) reports that Lotka's Law does not fit the literature in medicine. (Radhakrishnan & Kernizan, 1979) find that Lotka's Law does not apply well to computer science literature. They find that an exponent of 3 gives the best fit. In a subsequent study, however, (Subramanyam, 1979) argues that the computer science literature does confirm to Lotka's inverse square law if data are taken from a large collection of journals.

(Ahmad, Batcha, & Jahina, 2019) quantitatively identified the research productivity in the area of artificial intelligence at global level over the study period of ten years (2008-2017). The study identified the trends and characteristics of growth and collaboration pattern of artificial intelligence research output. Average growth rate of artificial intelligence per year increases at the rate of 0.862. The multi-authorship pattern in the study is found high and the average number of authors per paper is 3.31. Collaborative Index is noted to be the highest range in the year 2014 with 3.50. Mean CI during the period of study is 3.24. This is also supported by the mean degree of collaboration at the percentage of 0.83 .The mean CC observed is 0.4635. Lotka’s Law of authorship productivity is good for application in the field of artificial intelligence literature. The distribution frequency of the authorship follows the exact Lotka’s Inverse Law with the exponent á = 2. The modified form of the inverse square law, i.e., Inverse Power Law with á and C parameters as 2.84 and 0.8083 for artificial intelligence literature is applicable and appears to provide a good fit. Relative Growth Rate [Rt(P)] of an article gradually increases from -0.0002 to 1.5405, correspondingly the value of doubling time of the articles Dt(P) decreases from 1.0998 to 0.4499 (2008-2017). At the outset the study reveals the fact that the artificial intelligence literature research study is one of the emerging and blooming fields in the domain of information sciences.

(Batcha, 2018) study lights on Lotka's empirical law of scientific productivity that is inverse square law to measure the scientific productivity of authors, to test Lotka's exponent value and the K.S test for the fitness of Lotka's law and the result obtained in this study do not follow the inverse square law.

(Budd, 1988) applied the Lotka's and Bradford's laws to citations to journals in 569 papers on higher education it finds the conformity of higher education literature, as represented but the database used, is not perfect with the two bibliometric laws, but the results do suggest that the underlying concepts of the laws may have applicability to examination of the discipline.

(Naqvi & Fatima, 2017) analysed international business literature to study the applicability of Lotka's law to author productivity. Further, Kolmogorov –Smirnov goodness of fit test (K-S Test) and Chi square test also tested to compare and confirm the dataset. In both the cases, Lotka's law confirmed the author productivity distribution.

(Ahmed & Rahman, 2009) examined the validity of Lotka's Law to authorship distribution in the field of nutrition research in Bangladesh (1972-2006) using both generalized and modified models. The results suggest that author productivity distribution predicted in Lotka's generalized inverse square law is not applicable to nutrition research in Bangladesh. While, using LLS method excluding highly productive authors, Lotka's Law was found to be applicable to nutrition research in Bangladesh.

(Aswathy & Gopikuttan, 2013) assessed the author productivity in the publication of three Universities in Kerala during 2005-2009 and (Sudhier, 2013) evaluated the authorship distribution in physics literature. In both the study, Lotka's inverse square law has been applied using Pao's method and the data set was tested by K-S goodness-of-fit-test. But, the Lotka' generalised law is not applicable to these study.

Kumar (2010) examines the applicability of Lotka's Law as a general inverse power ($\alpha \neq 2$) and an inverse square power relationship ($\alpha = 2$) to the distribution of the research productivity in Council of Scientific and Industrial Research (CSIR), India. The results obtained in this study do not follow the inverse square law of Lotka as such and similarly (Gupta, Kumar, & Aggarwal, 1999) has also described in his studies based on CSIR samples that Lotka's formulation is not applicable in case of CSIR productivity distribution. It may be due to longer period of participation in research.

Objectives of the Study

The objectives of the present study are as follows

- To quantify the research output in the form of publications and average growth rate of literature in the field of Dyslexia literature over the study period of ten years (2009-2018).
- To analyse the authorship pattern and degree of Collaboration of research in the field of Dyslexia literature during the period of study.
- To analyse the research trend with Collaborative Co-efficient, Modulated Collaborative Co-efficient and Collaborative Index in the global literature of Dyslexia.
- To study the growth trend with the analysis of Relative Growth Rate (RGR) of publications;
- To find out the Doubling Time (DT) for the publications to become double of the existing amount;
- To test the applicability of Lotkas's Law in the author productivity.
- To determine whether the "n" value confirms to Lotka's Law through K- S test.

Methodology

The data for the present study was retrieved from Web of Science database in the past known as web of knowledge which is online subscription based scientific citation indexing service initially produced by the Institute for Scientific Information (ISI), and now maintained by Clarivate Analytics. The database was chosen primarily because of its exhaustive coverage of most reliable and authentic source, in addition to, representing one of the leading general indexing and abstracting sources. Dyslexia was used as a term to run the search at the Web of Science Core Collection with all probabilities and bibliographical details. The search was further confined to a period of ten year, i.e., 2009 through 2018. With this exercise a total of 5182 research papers collectively contributed by 21115 scientists published in 1014 scientific periodicals were collected for Scientometric analysis.

Analysis and Interpretation of the Results

Table 1 depicts the growth of research publications published in the field of Artificial Dyslexia literature during the study period 2009-2018. Altogether 5182 publications were published. The highest number of articles, 605 (11.68%) were published in the year 2018; while less number of

research articles 397 (7.66%) were published in the year 2009.The second highest number of articles, 601 were published in the year 2016 (11.60%). There is a steady growth found in research output from one year to proceeding next year. Further it is found that the average rate of increase in the number of publications per year is 0.96%.

Table 1 : Year Wise Distribution and Average Growth Rate of Publications in Dyslexia Literature

Year	Research Output	%	Cum. Output	Cum. %	Growth Rate
2009	397	7.66	397	7.66	
2010	452	8.72	849	16.38	0.88
2011	469	9.05	1318	25.43	0.96
2012	462	8.92	1780	34.35	1.02
2013	504	9.73	2284	44.08	0.92
2014	543	10.48	2827	54.55	0.93
2015	553	10.67	3380	65.23	0.98
2016	601	11.60	3981	76.82	0.92
2017	596	11.50	4577	88.32	1.01
2018	605	11.68	5182	100.00	0.99
Total	5182	100.00			0.96

Table 2 illustrates the year wise distribution of authorship pattern of global Dyslexia literature. Out of 5182 papers, the authorship pattern up to 10 authors results a total of 5026 research output remaining 156 papers have been published by more than ten authors. Single author contributions are accounted to 11.26% during the study period. The highest percentage of 20.71% is recorded by two authors followed by three and four authors showing 20.35 and 17.17 percentages respectively. However, more than six authors have contributed less than 10 percentages in this study. This analysis of results shows that individual contribution is not at the rate of appreciation compared to collaborative research up to six in the field of Dyslexia literature research. The number of authors engaging collaborative research is found increasing year by year from 2009 to 2018 ranging from 1485 to 2556. It can be noticed that 4.20 % of authors/scientists collectively contribute one paper in the field of Dyslexia literature.

Table 2 : Analysis of Authorship Pattern among the Scientists of Dyslexia Literature													
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**	**%**	**Total Authors**
2009	62	82	73	67	39	25	12	10	15	6	391	7.78	1485
2010	44	106	101	69	49	32	19	15	4	2	441	8.77	1732
2011	64	103	78	72	53	34	22	15	14	2	457	9.09	1848
2012	42	104	86	74	69	26	19	12	6	7	445	8.85	1891
2013	36	93	107	95	65	34	24	17	7	9	487	9.69	2212
2014	50	98	114	97	73	39	25	12	10	4	522	10.39	2366
2015	71	129	113	98	55	29	19	11	10	3	538	10.70	2042
2016	74	108	119	96	83	40	24	15	16	7	582	11.58	2468
2017	62	101	120	101	74	47	34	23	7	9	578	11.50	2515
2018	61	117	112	94	72	48	42	13	17	9	585	11.64	2556
Total	566	1041	1023	863	632	354	240	143	106	58	5026	100.00	21115
%	11.26	20.71	20.35	17.17	12.57	7.04	4.78	2.85	2.11	1.15	100.00	*AAPP	4.20

*AAPP – Average author per paper

Collaborative Index (CI)

(Lawani,1986) proposed and coined the term Collaborative Index to describe the average number of authors per paper for a given set of papers and used it as a quantitative measure of research collaboration. It can be calculated easily, but it cannot be interpreted as a degree because it has no upper- value limit. It is denoted by the formula:

$$C = \frac{\text{Total Number of Authors}}{\text{Total Number of Papers}}$$

Degree of Collaboration (DC)

Subramanyam propounded the DC, a measure to calculate the proportion of single and multi-author papers and to interpret it as a degree. According to Subramanyam (1983),

$$\text{DC} = \frac{\text{Nm}}{\text{Ns+Nm}} \qquad \frac{\text{No of Muti-authored papers}}{\text{No of Single+No of Multi-authored Papers}}$$

Co-Authorship Index (CAI)

To study the shift in the pattern of co-authorship during 2008-2017 CAI suggested by (Garg & Padhi, 2001) was used

CAI is computed as follows:

$$CAI = \left[\frac{\left(\frac{N_{ij}}{N_{io}} \right)}{\left(\frac{N_{oj}}{N_{oo}} \right)} \right] \times 100$$

Where Nij: number of papers having j authors in year/block;

Nio : total output of year block i;

Noj : number of papers having j authors for all years/blocks;

Noo : total number of papers for all authors and all years/blocks.

J = 2, (3 or 4), >= 5

Collaboration Co-efficient (CC)

(Ajiferuke et al., 1988) suggested a single measure to measure collaborative research and termed it as collaborative co-efficient. The method is based on fractional productivity defined by Price and Beaver .The following formula denotes CC. The symbols used have been explained as under:

$$CC = 1 - \frac{\sum_j^k (1/j) f_j}{N}$$

Where f_j is the number of j authored papers; N is the total number of research papers published and k is the greatest number of authors per paper according to Ajiferuke, CC tends to zero as single authored papers dominate and to 1-1/j as j-authored papers dominate. This implies that higher the value of CC, higher the probability of papers with multi or mega authors.

Modified Collaboration Co-efficient (MCC)

(Sayanur and Srikanth, 2010) modified the CC and derived MCC as follows:

$$MCC = \frac{A}{A-1} 1 - \frac{\sum_j^k (1/j) f_j}{N}$$

Table 3 attempts to analyse different collaboration factors for the period of 10 years (2009-2018). The analysis of the table includes CI, DC, CAI, CC, and MCC. The Table shows

collaborative Index at the lowest level in the year 2009. Collaborative Index is highest in the year 2013 and mean CI during the time of study is 4.20. Subramanyam propounded the DC, a measure to calculate the proportion of single and multi-author papers and to interpret it as a degree. DC varies from 0 when all the papers have a single author to 1 when all the papers have more than one author. It can be easily calculated and can also be easily interpreted.

Table 3 :Analysis of Collaboration factors in Dyslexia Publication at Global Level

Authorship Pattern	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Total**
1	62	44	64	42	36	50	71	74	62	61	566
2	82	106	103	104	93	98	129	108	101	117	1041
3	73	101	78	86	107	114	113	119	120	112	1023
4	67	69	72	74	95	97	98	96	101	94	863
5	39	49	53	69	65	73	55	83	74	72	632
6	25	32	34	26	34	39	29	40	47	48	354
7	12	19	22	19	24	25	19	24	34	42	240
8	10	15	15	12	17	12	11	15	23	13	143
9	15	4	14	6	7	10	10	16	7	17	106
10	6	2	2	7	9	4	3	7	9	9	58
Total Papers	391	441	457	445	487	522	538	582	578	585	5026
Total Authors	1485	1732	1848	1891	2212	2366	2042	2468	2515	2556	21115
CI*	3.80	3.93	4.04	4.25	4.54	4.53	3.80	4.24	4.35	4.37	4.20
DC+	0.84	0.90	0.86	0.91	0.93	0.90	0.87	0.87	0.89	0.90	0.89
CAI!	94.82	101.5	96.91	102.05	104.36	101.9	97.82	98.36	100.6	100.9	100
CC#	0.5875	0.618	0.601	0.6295	0.6554	0.6381	0.5929	0.617	0.637	0.636	0.6223
MCC$	0.5890	0.620	0.602	0.6309	0.6567	0.6393	0.5940	0.618	0.6381	0.637	0.6224
MCC-CC	0.0015	0.0014	0.0013	0.0014	0.0013	0.0012	0.0011	0.0011	0.0011	0.0011	0.0001

CI* - Collaborative Index, DC+ - Degree of Collaboration, CAI! – Co-authorship Index, CC# - Collaborative Co-efficient, MCC$ - Modified Collaborative Co-efficient

It is found in this study that DC was lowest at 0.84 in 2009 and highest at 0.91 in 2012. In all the year multi-authored papers are steadily increasing and in 2009 it is at its lowest and hence the mean DC during the study period shows 0.89. The value of CAI in the first year starts with 94.82 and it fluctuates in respect of other proceeding years as multi and mega authored papers increase and fluctuation. This implied that during the study period single authored papers are fluctuating at the scenario. The CAI increase in the year 2010 is 101.5 and then in year 2011 it again decreases and from year 2012 to 2014 it steadily increases from 102.05, 104.36 and 101.9

respectively. It again goes down in 2015, 2016 and shows little bit growth in the last two years. This result is supported with the outcome of CC. In this study, CC is also lowest in 2009 showing 0. 5875. It is at the highest rate of 0.6554 in 2013. The mean CC is 0.6223.

The study found MCC was lowest in 2009, when it was 0.5890. It was at the highest value of 0.6567 in 2013.The mean MCC during the period of study was 0.6224. It is also observed from the table that the mean difference between CC and MCC is 0.0001. Least difference between CC and MCC, i.e. 0.0011 is observed during the years 2015, 2016, 2017, and 2018. The highest difference CC and MCC, which is 0.0015, is observed in the year 2009. It can be concluded that no significant difference can be observed between CC values and MCC values, and also this variation narrows down when the number of authorships increases.

Out of 5182 articles published, single author share is 566 and multiple paper author shares is 4616. This indicates that single paper contribution is less than multiple author papers. It can be summarized from the above discussion that very high collaborative research activities are observed in global Dyslexia literature.

Lotka's Law

Lotka's Law is one of the most basic laws of bibliometrics, which deals with the frequency of publication of authors in and given field. The generalized form of Lotka's law can be expressed as

Y = (C)

Where Y is the number of authors with X articles, the exponent n and constant C are parameters to be estimated from a given set of author productivity data.

Lotka's law describes the frequency of publication by authors in a given field. It states that the number of authors making n contribution is about $1/n^2$ on those making one and the proportion of all contributions that make a single contributions, is about 60 percent (Potter, 1981) **.** This means that out of all the authors in a given field, 60 percent will have just one publication and 15 percent will have two publications. 7 percent of authors will have three publications and so on. According to Lotka's law of scientific productivity, only six percent the authors in a field will produce more than 10 articles.

While theoretical Lotka's value is á = 2.00

Theoretical value of ‘n’ 2.31 is matched with table value of R. Rosseau for getting C.S. value 0.7007

Constant Value of Present Study	n Value
0.7007	2.31
Lotka’s Constant Value	n Value
0.6079	2

D-Max Value Present Study	D-Max Value of Lotka’s Study
0.0325	0.1314

To test the goodness of fit, weather the observed author productivity distribution is not significantly different from theoretical distribution. K-S test applied. According to this test, the maximum deviation is observed and estimated value D-Max is calculated follows:

D_{Max} = F(x) – En(x) á = 2.31

Theoretical Value of C = 0.7007 Fe+ = $0.7007\left(\frac{1}{x^{2.31}}\right)$

D-Max = 0.0325

Critical Value at 0.01 level of significance = $\frac{2.31}{\sqrt{10826}} = 0.0222$

Table 4: Analysis of Lotkas's Exponent Value on Dyslexia Research Output

x	**y**	**X=Log X**	**Y=Log Y**	**XY**	**X^2**
1	7938	0.000000000	3.899711095	0.000000000	0.000000000
2	1430	0.301029996	3.155336037	0.949850794	0.090619058
3	605	0.477121255	2.781755375	1.327234615	0.227644692
4	293	0.602059991	2.466867620	1.485202298	0.362476233
5	198	0.698970004	2.296665190	1.605300078	0.488559067
6	107	0.778151250	2.029383778	1.579167524	0.605519368
7	104	0.845098040	2.017033339	1.704590922	0.714190697
8	76	0.903089987	1.880813592	1.698543923	0.815571525

9	42	0.954242509	1.623249290	1.548973476	0.910578767
10	33	1.000000000	1.518513940	1.518513940	1.000000000
		6.559763033	23.66932926	13.41737757	5.215159407
		ΣX	ΣY	ΣXY	ΣX^2

The theoretical value of C as 0.7007 for á = 2.31 is taken from the book 'Power Laws in the Information Production Process: Lotkaian Informetrics' by Egghe (2005). The K-S test is applied for the fitness of Lotka's law fits to the global Dyslexia research output. Result indicates that the value of D- Max, i.e. 0.0325 determined with Lotka's exponent á = 2.31 for Dyslexia which is not close and shows high to the D-Max value 0.1253 determined with the Lotka's exponent á = 2 than the critical value determined at the 0.01 level of significance, i.e., 0.0222. Thus, distribution frequency of the authorship follows the exact Lotka's inverse law with the exponent á = 2. The modified form of the inverse square law, i.e., inverse power law with á and C parameters as 2.31 and 0.7007 for Dyslexia literature is applicable and appears to provide a good fit.

Table 5: K-S Test of Observed and Expected Distribution of Authors

x	Y	Observed=yx/Σxy	Value=Σ(yx/Σyx)	Expected Freq	Value of Freq/Cum	Diff(D)	Expected Freq	Value of Freq/Cum	Diff(D)
1	7938	0.733234805	0.733234805	0.7007	0.7007	0.0325	0.6079	0.6079	0.1253
2	1430	0.132089414	0.865324219	0.1411	0.8418	-0.0090	0.1520	0.7599	-0.0199
3	605	0.055883983	0.921208202	0.0552	0.8970	0.0006	0.0675	0.8274	-0.0117
4	293	0.027064474	0.948272677	0.0284	0.9254	-0.0013	0.0380	0.8654	-0.0109
5	198	0.018289304	0.96656198	0.0170	0.9424	0.0013	0.0243	0.8897	-0.0060
6	107	0.009883614	0.976445594	0.0111	0.9535	-0.0012	0.0169	0.9066	-0.0070
7	104	0.009606503	0.986052097	0.0078	0.9613	0.0018	0.0124	0.9190	-0.0028
8	76	0.007020137	0.993072233	0.0057	0.9670	0.0013	0.0095	0.9285	-0.0025
9	42	0.003879549	0.996951783	0.0044	0.9713	-0.0005	0.0075	0.9360	-0.0036
10	33	0.003048217	1.000000000	0.0034	0.9748	-0.0004	0.0061	0.9421	-0.0030
Total	10826		Present study's		D.Max = 0.0325		Lotka's	D.Max = 0.1253	

Relative Growth Rate (RGR)

Relative Growth Rate (RGR) means the increase in the number of articles per unit of time. The mean RGR of articles over the specific period of interval which is mathematically given by:

Rt(P) = [logP(t)-logP(0)]

Rt = Relative growth rate of articles over the specific period of time.

LogP (0) = Logarithm of initial number of articles logP (t)

= Logarithm of final number of articles.

Doubling Time

Doubling time is defined as the time required for the articles to become double of the existing amount. It has been calculated using following formula:

Dt is given by (t) =0.693/R

Where R is relative growth rate of articles

Dt = It is directly related to RGR.

Table 6 clearly indicates the average Relative Growth Rate Rt (P) and Doubling time of articles in Dyslexia literature during the study period. It is observed that the value of relative growth rate of an article has gradually increased from 2009 (1.672) to 2018 (3.422) and in that order the value of doubling time of the articles Dt(P) gradually decreased from 0.4144 year (2009) to 0.2025 year (2018). The mean relative growth rate Rt(P) of articles for the first five years (from 2009 to 2013) was 1.8734. It increased to 3.1998 for the next five years (from 2014 to 2018), whereas for the doubling time of the articles Dt(P) for the first five years (from 2009 to 2013) indicates 0.3081 has gradually decreased for the next five years (from 2014 to 2018) to 0.2171. It can be concluded from the above analysis that relative growth rate of articles has been gradually increased and on the other hand, doubling time of the articles has been gradually decreased.

Table 6 : Relative Growth Rate and Doubling Time of Global Dyslexia Literature								
Year	**Research Output**	**Cum. Output**	**W1**	**W2**	**RT(p)**	**Mean RP(p)**	**Dt(p)**	**Mean Dt(p)**
2009	397	397	5.9839	5.984	0.000			
2010	452	2407	6.1137	7.786	1.672		0.4144	
2011	469	4418	6.1506	8.393	2.243	1.8734	0.3090	0.3081
2012	462	6430	6.1356	8.769	2.633		0.2632	
2013	504	8443	6.2226	9.041	2.819		0.2459	
2014	543	10457	6.2971	9.255	2.958		0.2343	
2015	553	12472	6.3154	9.431	3.116		0.2224	
2016	601	14488	6.3986	9.581	3.182	3.1998	0.2178	0.2171
2017	596	16505	6.3902	9.711	3.321		0.2087	
2018	605	18523	6.4052	9.827	3.422		0.2025	
Total	5182					2.5366		0.2626

Conclusion

The study quantitatively identified the research productivity in the area of Dyslexia at global level over the study period of ten years (2009-2018). The study identified the trends and characteristics of growth and collaboration pattern of Dyslexia research output. Average growth rate of Dyslexia per year increases at the rate of 0.96. The multi-authorship pattern in the study is found high and the average number of authors per paper is 4.20. Collaborative Index is noted to be the highest range in the year 2013 with 4.54. Mean CI during the period of study is 4.20. This is also supported by the mean degree of collaboration at the percentage of 0.89 .The mean CC observed is 0.6223. Lotka's Law of authorship productivity is good for application in the field of Dyslexia literature. The distribution frequency of the authorship follows the exact Lotka's Inverse Law with the exponent á = 2. The modified form of the inverse square law, i.e., Inverse Power Law with á and C parameters as 2.31 and 0.7007 for Dyslexia literature is applicable and appears to provide a good fit. Relative Growth Rate [Rt(P)] of an article gradually increases from 1.672 to 3.422, correspondingly the value of doubling time of the articles Dt(P) decreases from 0.4144 to 0.2025 (2009-2018). At the outset the study reveals the fact that the Dyslexia literature research study is one of the emerging and blooming fields in the domain of information sciences.

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