

Article

A Data-Driven Critical Review of Second Language Acquisition in the Past 30 Years

Meng-Lin Chen 

Department of Translation and Interpretation Studies, Chang Jung Christian University, Tainan 71101, Taiwan; menglin@mail.cjcu.edu.tw; Tel.: +886-0627-85123 (ext. 4052)

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Abstract: This study aims to provide a comprehensive and data-driven review of the knowledge domain of second language acquisition (SLA) and pedagogy in the past 30 years. Using knowledge domain visualization techniques, the study first provides a review of SLA at the disciplinary level. It then identifies the major research areas and current research frontiers in the SLA research landscape based on high-quality data retrieved from Web of Science (WoS) databases. The study provides useful references for future research and pedagogy in the field in which literature reviews employing scientometric methodology and driven by data, such as the present one, are rare, and thus, are much in need of supplement views produced by traditional literature reviews.

Keywords: SLA; L2 acquisition; critical review; research themes; discipline; scientometric methodology

1. Introduction

Second language acquisition (SLA), or L2 (language 2) acquisition, studies the learning process of any language other than a person's first language. Although strictly speaking, the word acquisition does not refer to the conscious learning or the teaching of a language [1], and the phrase second language differs from foreign language [2], researchers have used both word pairs—learning/acquisition and second language/foreign language—as synonyms, and they have also extended SLA to include the learning process of the third, fourth, or subsequent languages [3–5]. However, SLA has been preferred by most researchers in this discipline.

VanPatten and Benati suggest that two works, Corder's *The Significance of Learners' Errors* [6] and Selinker's *Interlanguage* [7], mark the beginning of the modern study of SLA as a scientific discipline [8] (pp. 2–5). Corder's systematic analysis of learner errors provides empirical evidence on how a language is learned [6]. Selinker defines interlanguage as a learner language system with its own right and a complete set of rules which is different from the languages that learners already know [7]. Both works are regarded as facilitating the development of SLA from a branch of applied linguistics into an academic discipline built upon linguistics, psychology, cognitive psychology, sociology, sociolinguistics, and education [4,9].

Approaches and theories of SLA have been introduced and extensively elaborated upon in a large amount of works, including but not limited to Ellis [2], Gass and Selinker [10], Larsen-Freeman and Long [11], and Ortega [5], and VanPatten and Williams [12]. Some of the prominent areas included in the works are Contrastive Linguistics Hypothesis [13], Error Analysis [6], Interlanguage Theory [7], Monitor Theory [1,14], Zone of Proximal Development (ZPD) [15], Universal Grammar and Minimalist Program [16,17], Corpus Linguistics [18–21], and Cognitive Approach [2]. The following is a brief introduction to some of the most important works in the SLA field. The introduction will be arranged according to a chronological order.

The contrastive linguistic approach in SLA develops from the Contrastive Linguistic Hypothesis [13], which dates back to Saussure's structuralism [22] and Bloomfield's behaviorism [23].

The hypothesis proposes that differences between languages cause “negative transfer” while linguistic proximity promotes “positive transfer”. Difficulties in learning a language are thus predictable by a systematic comparison of the learner’s native and the second language systems in terms of grammar, phonology, and lexicon [13]. The Contrastive Linguistic Hypothesis has led to other important hypotheses and theories in SLA such as the Critical Period Hypothesis of the appropriate age for learning a language [24,25]. Although the contrastive linguistic approach has been criticized for being unable to explain language difficulties at the cognitive level and failing to predict some learner errors, it is still a focus of ongoing debates regarding the definition of language transfer, the nature of language transfer, and its position and role in second language teaching and learning [5].

Extending the contrastive linguistic approach, Corder proposes that Error Analysis is a more direct and effective method to study SLA processes [6]. She distinguishes accidental and random errors from those generated by learners at different learning stages. A systematic analysis of learner errors points out at what stage the learner has reached in learning a second language and provides researchers with evidence of how language is learned. However, as pointed out by Schachter, Error Analysis basically ignores the input (listening and reading), which makes it impossible to assess the learner’s language development [26].

Selinker puts forward Interlanguage Theory that looks at the learner’s language as a relatively independent language system based on Contrastive Linguistics and Error Analysis [7]. Interlanguage refers to the language produced by learners before they reach near-native or native-like fluency in the target language. Selinker uses five processes to describe the causes of Interlanguage: language transfer, transfer caused by training, the generalization of target language rules, learning strategies, and communication strategies [7]. Interlanguage Theory is an earlier theoretical model that explains second language acquisition from a cognitive perspective. Its significance lies, first of all, in that it regards SLA as a psychological process and provides a theoretical framework to explain the occurrence of this psychological process. Additionally, this theoretical framework has proved a sound basis for the later study of SLA using experimental methods [10].

In the 1980s, the field of SLA saw the development of Krashen’s Monitor Theory, which includes 5 hypotheses [1,14]:

1. Acquisition/Learning Hypothesis. It proposes that “adults have two distinct and independent ways of developing competence in a second language” [1] (p. 65). Acquisition refers to the subconscious way, while learning is the conscious way.
2. Natural Order Hypothesis. It claims that if learners learn a second language through natural means, their learning order will show a high degree of predictability.
3. Monitor Hypothesis. It states that monitoring or editing is the only purpose for our conscious to learn the rules of a language.
4. Input Hypothesis. In contrast to error analysis, this hypothesis claims that comprehensible input is the most important factor for learners to acquire a second language.
5. Affective Filter Hypothesis. It states that in addition to comprehensible input, the acquisition of a language depends on the learner’s emotions, needs, attitude, and motivations for second language learning.

Despite its many deficiencies, Monitor Theory has played a significant role in promoting the development of SLA theory and teaching and has a higher or lower impact on the development of a number of other important hypotheses such as Swain’s Comprehensible Output Hypothesis [27] and Schmidt’s Noticing Hypothesis [28]. In particular, the Input Hypothesis and Affective Filter Hypothesis have both had an important practical significance to language teaching and practice [11].

Corpus Linguistics, an interdisciplinary field, has attracted a great deal of attention since the 1980s [18–21]. It studies the collection, storage, processing and statistical analysis of natural language texts in order to engage in linguistic research with objective and informative linguistic evidence provided by large-scale corpora [29]. According to Chen [30], there are 5 major research streams

of corpus linguistic studies in SLA (i.e., lexical acquisition, language acquisition, cognitive studies, vocabulary teaching and learning, and corpora) in the classroom. Although corpus linguistics has its own unique theoretical system and methodology, it is not yet regarded as a distinct branch of linguistics, but rather a research method [31,32].

Modern SLA research has turned to cognitive approaches, and the most important model in respective a cognitive approach is Ellis's [2] computational model [8]. According to Ellis, the learning process starts with a first stage where certain features of the language are deposited in the learner's short-term memory through input [2]. In the next stage, some of the deposits are converted into second-language knowledge and stored in the learner's long-term memory. In the third stage, the learner uses the second language knowledge to produce output. Cognitive theories attempt to explore the mental representations and underlying process of the above 3 stages.

In addition, there are linguistic and sociocultural approaches to SLA (i.e., Chomsky's [16] Universal Grammar (UG) and Vygotsky's [15] Zone of Proximal Development (ZPD) [8]). The central idea of UG is that the human brain has a congenitally specific structure or attribute, that is, a language acquisition mechanism, which is the internal reason why humans learn to use language [16]. Within UG, a major mode of inquiry has developed into the Minimalist Program, basically, a conceptual framework that guides the inquiry of linguistic theory [17]. On the other hand, ZPD is regarded as a unique sociocultural approach to SLA studies. It suggests that learners who interact with more advanced target language users will learn the language more efficiently than those who learn the language independently [15].

It is clear that SLA is closely related to many social-science fields, such as linguistics, psychology, psycholinguistics, pragmatics, education, sociology, sociolinguistics, and cognitive psychology. In the future, it will have a tendency to integrate with the natural sciences such as cognitive science, neuroscience, and neurobiology. It is expected that new research methods, such as mathematics, statistical analysis, and computational analysis, will be widely used in SLA research [8].

In the multidisciplinary field of SLA study, regular reviews of previous research are considered instrumental because the advancement of knowledge relies on an accumulation of individual theoretical and empirical studies [30]. However, previous reviews of SLA research [3,8,33–38] have been mainly qualitative in nature. They often emphasized a few research themes depending on the author's preferences, and they might not capture emerging SLA developments in a timely manner. For example, Archibald et al. [3] looked at content-based learning; Hucking and Coady [34], the vocabulary acquisition; and, Weinert [38], the role of formulaic language. Although a few studies were data-driven, they were also focused on smaller SLA areas, (e.g., the use of corpora in SLA by Chen [30]). It has been argued that SLA lacks a clearly-defined research scope, and comprehensive literature reviews are much in need to facilitate the dialogue between researchers who take different research perspectives and methods [8].

In recent years, a number of bibliometric studies have emerged in the neighboring fields of SLA that provide fresh, comprehensive views of their respective fields of study [30,39–41]. For example, Lei and Liu identified 165 of the most popular research topics discussed by 10,028 articles published in 42 Social Science Citation Index journals related with Applied Linguistics [41]. They found that most of the frequently discussed topics in applied linguistics remained popular between 2005 and 2016, including communicative competence, academic discourse, vocabulary acquisition, discourse analysis, corpus-based studies, etc. While some topics related to socio-cultural issues (e.g., language policy, multilingualism, and ideology) experienced a significant increase in interest, the focus on topics concerning phonology, grammar, generative linguistics decreased significantly. In addition, neither a significant increase nor a significant decrease was found in traditional linguistic research topics such as collaborative writing, education policy, interactional feedback, and universal grammar. They further argued that the research trend of applied linguistics tended to turn to "sociocultural and language policy issues" from "some formal linguistic issues, such as phonology and syntax" [41] (p. 9). These findings from applied linguistics are of great importance and interest to the current study, and they are worth further exploration using SLA data. There were also bibliometric studies that

thoroughly examined the publication output, trends and collaboration of authors in the academic disciplines of linguistics [42], world Englishes [43], and second language writing [44]. These studies show that the bibliometric approach is powerful in revealing research trends in language-related fields with findings that qualitative analysis cannot yield.

In addition, in her bibliometric study of corpus-based studies of second/foreign language, Chen [30] identified 4 research trends in corpus-based SLA studies including the writing of second language learners, the construction of corpora, vocabulary teaching and learning, and the production process of both first language and second language learners. However, this study was quite specific, and it provided little in the way of information on the development of SLA as a field of study.

Given the advantage of a bibliometric approach to provide a more comprehensive examination of the literature in a discipline and the lack of a discipline-specific bibliometric review in SLA, this study used CiteSpace [45], a bibliometric visualization software package, to analyze the bibliometric information in the academic papers published from 1987 to 2018 in journals indexed by Web of Science (WoS) databases. The wide range of data sources and the bibliometric visualization method provided a complete and intuitive overview of the research areas, development and evolution process, and research hot-spots in SLA. The specific objectives of the study were to analyze the location of SLA in the broad scientific knowledge domain; establish the research areas in SLA through co-citations analysis; and identify landmark articles and determine the emerging trends in SLA research. The study is of significance for the researcher if only to better understand and grasp the primary research directions in this field.

2. Materials and Methods

The methodological process of this study included four stages: (1) retrieval of bibliographic data; (2) dual-mapping overlay to map SLA at the disciplinary level; (3) clusters analysis based on bibliographic information of co-cited articles to identify research areas and research frontiers (4) identification of pivotal works through burst detection, and (5) a timeline analysis and burst detection on co-cited keywords to identify important keywords.

2.1. Data Collection

A total of 11,381 references were obtained. The reference data used in this paper were retrieved from the Web of Science databases using the following retrieval strategies:

- The subject was set to the following: (second language acquisition) OR (L2 acquisition) OR (second language learn*) OR (L2 learn*) OR (foreign language acquisition) OR (foreign language learn*);
- The publication period was set from “between year 1900 and 2018” (Retrieved date 10 January 2018);
- Reference type was set to “article or proceedings paper”; language, “English”;
- Data category was refined by the subjects of “linguistics” or “education educational research” or “language linguistics”.

2.2. Data Analysis

CiteSpace provides a range of analytical tools to detect thematic patterns and emerging trends [45]. The following analytical tools were used in this study.

2.3. Dual-Mapping Overlays

The term ‘dual-map’ refers to the citing and cited component maps in the overall visualization. Given a set of articles, an overlay of the set visualizes the disciplinary concentrations of these articles and how they connect to various regions on the global map through their citation links [46].

2.4. Co-Citation Analysis

Citespace co-citation or co-occurrence analyses can be applied to different factors, such as cited reference, co-word, cited author, cited journal and so on. By studying these clusters and the relationships between these clusters in visual maps, some valuable information can be drawn.

In this study, we employed a co-citation analysis of references. The visual maps generated by Citespace were composed of nodes and links, respectively representing individual articles and co-citation between these articles. According to C. Chen's definition, the higher citation and centrality the node has, the larger impact the node has on the co-citation map [47].

2.5. Co-citation Timeline View

One of the main purposes of detecting emerging trends is to understand the flow of information among research areas: which areas contribute knowledge, and which areas are "borrowers" of knowledge. For this purpose, it is useful to track scientific paradigms as a function of time. Timeline views in CiteSpace II simultaneously show cited articles and citing times in order to highlight the mapping between a research front and its intellectual base [45].

3. Results and Discussion

3.1. The Location of SLA in Scientific Knowledge Domain

In order to display the maps of SLA at the disciplinary level, we employed the dual-map overlay technology [46] provided by CiteSpace to produce an easy-to-interpret representation of citations made by a wide variety of publications included in our dataset.

Figure 1 shows the patterns of SLA articles published between 1987 and 2018 against the global map of scientific literature that includes over 10,000 scientific journals reflecting a wide range of disciplines.

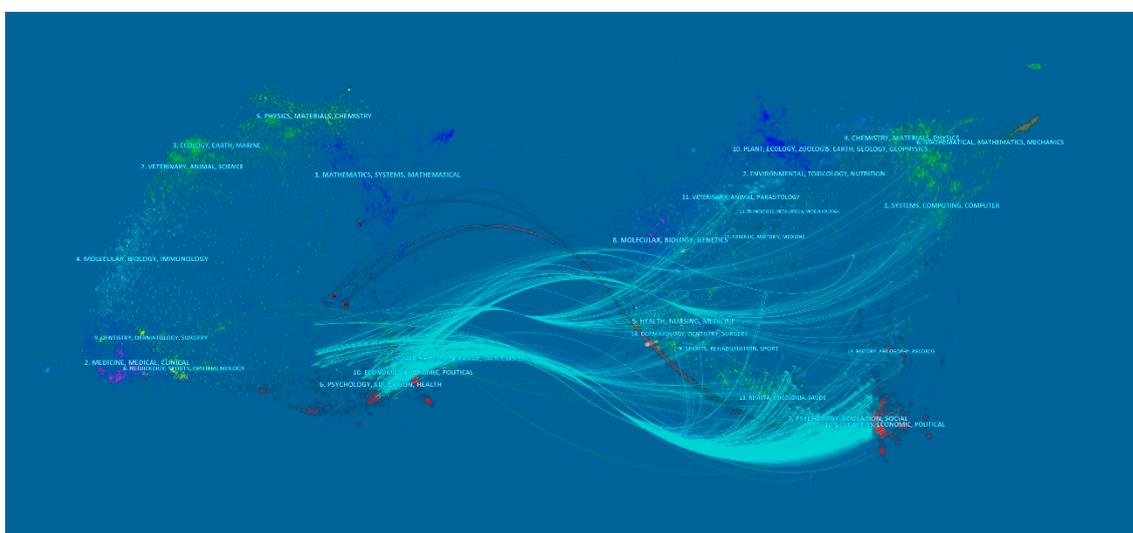


Figure 1. The location of second language acquisition in the knowledge domain.

In Figure 1, the left side is the distribution of journals (citing journals) in which a source article is published of the citing articles, which represents the main subject to which the SLA belongs; and, the right side corresponds to the distribution of journals (cited journals) in which a reference is published, which represents the main reference SLA subjects. Colored curves represent paths of references, originating from the map on the left and pointing to the cited-journals map on the right. The positions of the starting and ending points of these curves tell us about how an article has built

upon previous work because both citing and cited maps are divided into a number of thematic areas and each position on the map belongs to one of the given areas.

Figure 1 shows that the research literature of SLA primarily appears in the broad area near the left bottom on the citing map with the label of Psychology, Education, and Health. It is quite reasonable that articles in our dataset are mainly published in journals belonging to this category because it is the major discipline in social sciences and journals in this discipline usually publish studies of SLA. Citation curves that originate from the primary area on the left are split into a few major streams and point to numerous areas in the cited map on the right, indicating that articles in SLA journals cite distinct groups of journals, which include Psychology, Education, Health/Mathematical, Mathematics, Mechanics/Health, Nursing, Medicine/Systems, Computing, Computer/History, Philosophy, Records/Veterinary, Animal, Parasitology/Molecular, Biology, Genetics, etc.

In the early 1990s, when compared to other social sciences, SLA research was then a relatively new field, mostly borrowing from LI studies, pedagogical studies and methods of other related disciplines [48,49]. Gass found that most of the interaction between SLA and the other disciplines was unidirectional from other disciplines to SLA, which was not healthy for SLA development [48]. Nowadays, the results of our study show that the major publishers of SLA studies are journals concentrated in the category of “Psychology, Education, and Health” (the left side of the map in Figure 1), suggesting that SLA research is not much needed by disciplines of other knowledge categories. On the other hand, SLA research has greater “needs” from other disciplines as shown on the right side of the map in Figure 1. This indicates that the influence of SLA on other disciplines may not have increased much over the years. One obvious reason is that SLA is a more specific and narrower research field under the broader research disciplines of linguistics and education; and, SLA researchers will naturally “need” theories and studies of other established research disciplines such as psychology, mathematics, and computing. As pointed out by Gass, whether a discipline is “needed” by other disciplines is a measurement of the discipline’s integration with the academic community [48]. In this regards, a stronger interaction between SLA and other disciplines will lead to the contribution to the integration of the broader linguistics and education disciplines with other disciplines.

As a complement to this disciplinary view of SLA research, we also produced a geographic citation map as shown in Figure 2.

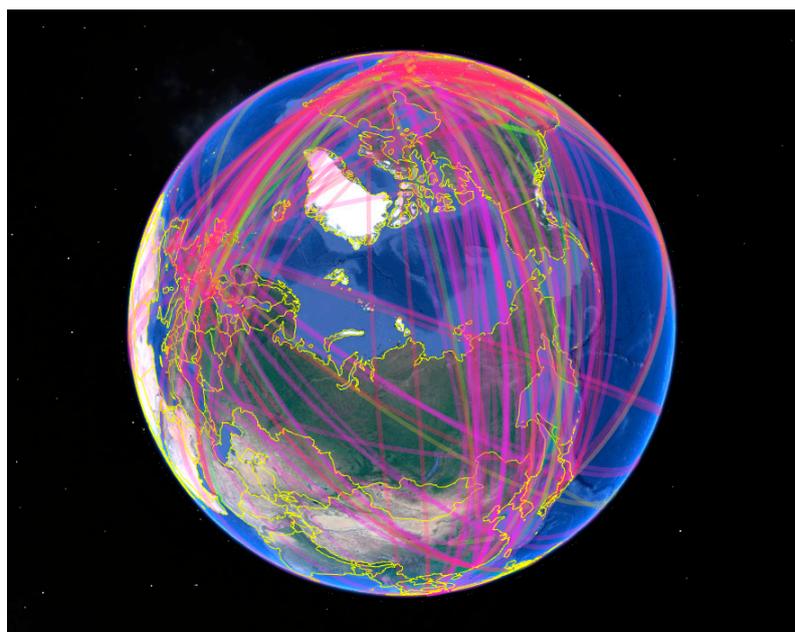


Figure 2. The global citation links in SLA.

Figure 2 gives the general distribution patterns of and network relations among the references in our dataset. The largest sources of publication in SLA are located in 3 major geographical regions: East Asia/Australasia, North America, and Europe. Each of the color links, which may consist of hundreds of thinner links, represents a citation relationship across the continents. At the global level, the citation relationship between East Asia/Australasia and North America is equally as strong as that between Europe and North America. However, the citation relationship between East Asia/Australasia and Europe is relatively weak, shown by the fewer color links. Since statistics of research and publication output are available from almost all major academic databases; statistical information of the links has been left out in this study.

3.2. The Major Areas of Research in SLA

To find out the major areas of research consistent with SLA, we carried out a co-citation analysis on the collection of publications in our dataset. After repeated testing, the synthesized network in Figure 3 was generated, containing 250,296 references. The map generated by this study produced a clearer structure with a better explanatory power ($Modularity^1 = 0.8119$; $Silhouette^2 = 0.6759$) when the following parameters were set:

- The time span was set from 1987 to 2018;
- The time partition was set to 8 years with a total of 4 time periods;
- The top 25 most frequently cited articles were selected in each time period; and
- The rest settings were left as default.

The clustering function was performed by choosing ‘T’ as the labeling source and the log-likelihood ratio (LLR) as the method. The results returned 20 knowledge clusters, 11 of which were major clusters labeled from #0 to #10. The cluster labels were generated automatically based on the LLR clustering algorithm. In order to increase the aesthetical effect of the mapping, we increased the transparency of nodes and links so that they were only shown in the background.

According to Chen [45], Modularity Q values between 0.4–0.8 are acceptable. The network in Figure 3 has a Modularity Q value of 0.8119 and a Mean Silhouette value of 0.6759, which are considered very high, suggesting that the research areas in SLA are clearly defined in terms of co-citation clusters.

The different colors of the areas indicate the time when co-citation links in those areas appeared for the first time. Areas in blue were generated earlier than areas in green. Areas in yellow were generated after the green areas and so on. Consequently, the two blue clusters (Clusters #1 and #3) are the oldest ones, and yellow clusters (#4, #5, and #9) are the most recent clusters. The most prominent cluster (Cluster #0) together with Clusters # 8 and #10 are relatively older ones, and Clusters #2, #6, and #7 are relatively recent ones. As CiteSpace’s clustering algorithm puts each topic into a single cluster instead of multiple clusters, the appearance of a topic in one period does not necessarily mean that this topic has not been popular in the past. For example, Cluster #9, which includes topics of reading comprehension and vocabulary, is suggested as one of the most recent clusters. In fact, reading comprehension and vocabulary have been found to be long-lasting popular research topics both in SLA and in applied linguistics [30,41]. Similarly, Cluster #7, which includes topics of usage-based approaches and working memory, is regarded as one of the relatively recent clusters that spanned from 2003 to 2010. However, usage-based approaches are still gaining an increasing level of current interest in recent years [41].

The above explanation only gives a brief overview of the major research areas in SLA from 1987 to 2018. The detail information of each major cluster is further provided in Appendix B, in which

¹ Modularity value measures the extent to which a network can be decomposed to multiple components, or modules

² The silhouette value of a cluster measures the quality of a clustering configuration. Its value ranges between -1 and 1 . The highest value represents a perfect solution.

the cluster size, publishing year, and cluster labels generated by other clustering algorithms (LSI and MI) are listed. The cluster labels generated by LSI and MI algorithms provided alternative views on the content of the clusters. However, they were too vague and essentially not meaningful enough for SLA. In the following, we will take a close look at these clusters to gain a better understanding of the research areas evolving over the years and provide tentative labels for them, as shown in Table 1.

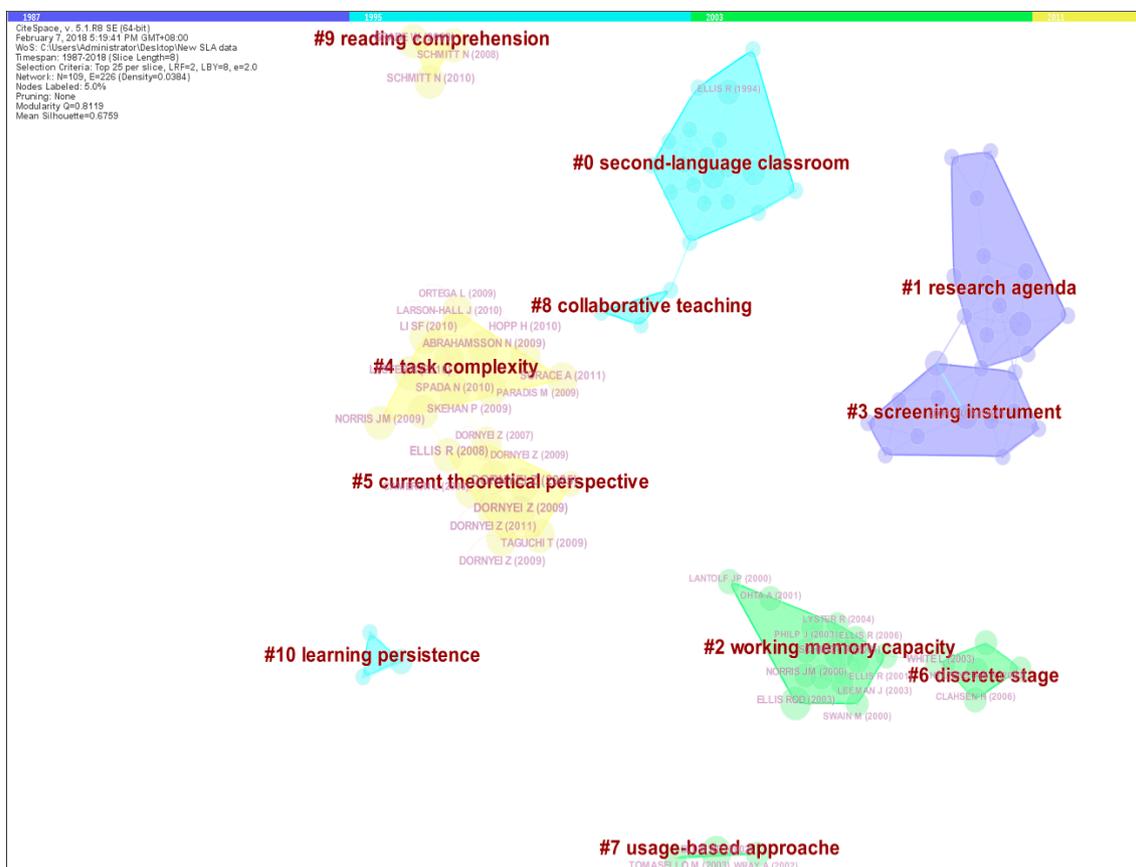


Figure 3. A clustered network of major research areas in SLA (1987–2018).

Table 1. The summary of the 11 largest clusters.

Cluster ID	Size	Silhouette	Mean (Year)	Label
0	19	0.917	1994	Cognitive SLA studies about second language classroom
1	14	0.936	1987	Theoretical SLA studies and their applications
2	14	0.943	2002	Methods of SLA teaching, learning, and research
3	12	0.916	1988	SLA studies of learner strategies
4	11	0.96	2009	Teaching approaches to complex tasks
5	10	0.947	2007	Psychology studies in SLA
6	5	0.973	2003	Linguistic and psycholinguistic approaches
7	3	1	2002	Usage-based approaches
8	3	0.925	1993	Collaborative teaching
9	3	1	2009	Reading and vocabulary
10	3	1	1994	Motivation in SLA

3.2.1. Cluster #0

This cluster is the largest and it contains 19 works, mostly published around 1994. The silhouette value of the cluster is 0.917, indicating a high consistency among the 19 cited works in this cluster.

Table 2 includes the node information within Cluster #0. Each node represents one cited reference. The node information for each cluster including Cluster #0 is extracted from Appendix C. This study will only briefly look at 3 works with the highest citation frequencies in the cluster.

Table 2. The members of Cluster #0.

ClusterID	Author	Year	Source	Freq.
0	Ellis R	1994	Study of second language acquisition	42
0	Tomlin RS	1994	Studies of second language acquisition	14
0	White L	1991	Second language research	15
0	Larsen-freeman D	1991	An introduction to second language acquisition research	14
0	Donato R	1994	Vygotskian approaches	18
0	Spade N	1993	Studies second language acquisition	13
0	Swain M	1995	Principle and practice in applied linguistics	18
0	Aljaafreh A	1994	Modern language journal	13
0	Pica T	1994	Language learning	25
0	Vanpatten B	1996	Input processing and grammar instruction	15
0	Schmidt R	1995	Attention awareness	13
0	Swain M	1995	Applied linguistics	21
0	Schmidt R	1993	Annual review of applied linguistics	13
0	Ellis R	1993	Tesol quarterly	14
0	Cadierno T	1993	Studies of second language	13
0	Lyster R	1997	Studies in second language acquisition	15
0	Long M	1998	Focus on form in classroom	17
0	Skehan P	1998	A cognitive approach to language learning	14
0	Doughty C	1998	Focus on form in classroom	16

Ellis's book, *The Study of Second Language Acquisition* [9], is referenced most frequently (42 times) by all the articles in our dataset. A general framework for SLA study is put forward in this book that covers essential SLA topics such as learner language, the linguistic environment, the learner's internal mechanisms, individual differences in language learning, and research on classroom second language acquisition. The second most-cited work in this cluster is Pica [50], an article published in the *Language learning* journal and has been cited 25 times. This review article looks at the development of SLA in the 1980s with a focus on the social interaction and negotiation of L2 learners with reference to SLA classrooms. It argues that classroom negotiation facilitates learners' comprehension and structural segmentation of L2 input which contributes to their learning outcome. The third most-cited is Swain and Lapkin [51], which is focused on the mental process that leads to modified learner output. It argues that noticing a problem can 'push' learners to modify their output. Other highly cited works contained in Cluster #0, such as Donato [52] and Long and Robinson [53], are all related to learner's cognitive process and Vygotsky's Zone of Proximal Development sociocultural theory [15]. Given that the rest of the works in this cluster cover classroom interaction [52], student attention [54], and the input process [55], a more appropriate label for Cluster #0 appears to be *Cognitive SLA Studies About Second Language Classroom*.

3.2.2. Cluster #1

As shown in Table 1, the 2nd largest cluster (#1) has 14 members and a silhouette value of 0.936. The mean publishing year of the 14 works is 1987, and the detailed information of the works is listed in Table 3 with the top 3 most frequently cited works highlighted.

Table 3. The members of Cluster #1.

ClusterID	Author	Year	Source	Freq.
1	Ellis R	1985	Understanding second language	9
1	Pica T	1987	Tesol quarterly	8
1	Swain M	1985	Input second language acquisition	7
1	Doughty C	1986	Tesol quarterly	9
1	Chomsky N	1986	Knowledge of language	9
1	Cazden CB	1988	Classroom discourse	7
1	White L	1987	Applied linguistics	8
1	Cook V	1988	Chomskys universal grammar	7
1	White L	1989	Universal grammar and second language acquisition	10
1	Pica T	1989	Studies in second language acquisition	10
1	Schmidt RW	1990	Applied linguistics	7
1	Chaudron C	1988	Second language classroom	21
1	Ellis R	1990	Instructed second language acquisition	11
1	Larsen-freeman D	1991	An introduction to second language acquisition research	11

Chaudron [56] reviews work on classroom-centered research and explains why student and teacher behaviors affect language learning with methodological discussions. Ellis [57] reviews classroom learning research and proposes a theory of instructed second language acquisition which has significant implications for language teaching. Taking a social and psycholinguistic perspective, Larsen-Freeman and Long [49] look at the empirical findings related to SLA by children and adults with an emphasis on how to design and carry out research in SLA. As this cluster also contains some important theoretical works such as Swain's Comprehensible Output Hypothesis [27] and Chomsky's and White's discussion of language origins [16,58], *Theoretical SLA Studies and Their Applications* appears to be a more appropriate label.

3.2.3. Cluster #2

As shown in Table 1, the 3rd largest cluster (#2) has 14 members and a silhouette value of 0.943. The mean publishing year of the 14 works is 2002, and the detailed information of the works is listed in Table 4 with the top 3 most frequently cited works highlighted.

Table 4. The members of Cluster #2.

ClusterID	Author	Year	Source	Freq.
2	Swain M	2000	Sociocultural theory and second language learning	41
2	Lantolf JP	2000	Sociocultural theory and second language learning	30
2	Norris JM	2000	Language learning	50
2	Carroll S	2001	Input and evidence: The raw material of second language acquisition	29
2	Schmidt R	2001	Cognition and second language instruction	59
2	Ohta A	2001	Second language acquisition	30
2	Ellis R	2003	Task-based language learning and teaching	55
2	Ellis R	2001	Language learning	30
2	Nicholas H	2001	Language learning	29
2	Leeman J	2003	Studies in second language acquisition	39
2	Philp J	2003	Studies in second language acquisition	38
2	Lyster R	2004	Studies in second language acquisition	35
2	Ellis R	2006	The study of second language acquisition	30
2	Swain M	2005	Handbook of research in second language teaching and learning	29

Schmidt [59] claims that attention or attended learning is far superior to other forms of learning and it holds the key to understand SLA and the development of interlanguage. Ellis's *Task-Based Language Learning* (TBLL) [60] is the state-of-the-art work in language learning and teaching, and it is no doubt one of the most influential theories in SLA that postulates the relationship between task and SLA, social aspects of TBLL, course design, teaching methodology, and the evaluation process. Norris and Ortega [61] carry out a meta-analysis to summarize both experimental and quasi-experimental studies into SLA instruction between 1980 and 1998. The other highly cited

works in this cluster provide critical reviews of the research into Input Hypothesis [62,63], Output Hypothesis [64], and the social contexts of SLA teaching and learning [65]. In summary, works in this cluster are related with SLA teaching, learning, and research, and it is more appropriate to be labeled as *Methods of SLA Teaching, Learning, and Research*.

3.2.4. Cluster #3

As shown in Table 1, the 4th largest cluster (#3) has 12 members and a silhouette value of 0.916. The mean publishing year of the 12 works is 1988, and other detailed information of the works is listed in Table 5 with the top 3 most frequently cited works highlighted.

Table 5. The Members of Cluster #3.

ClusterID	Author	Year	Source	Freq.
3	Ellis R	1986	Understanding second language acquisition	7
3	Gardner R	1985	Social psychology and second language learning	11
3	Horwitz EK	1986	Modern language journal	10
3	Wenden A	1987	Learner strategies in language learning	8
3	Oxford R	1990	Language learning strategies	35
3	Brown HD	1987	Principles of language learning and teaching	7
3	Omalley JM	1990	Learning strategies	24
3	Sparks R	1989	Annals of dyslexia	8
3	Spolsky B	1989	Conditions for language revitalization	7
3	Skehan P	1989	Individual differences in second language learning	7
3	Sparks RL	1991	Modern language journal	7
3	Bachman LF	1990	Fundamental considerations in language testing	7

Both Oxford [66] and O'Malley and Chamot [67] explore learning strategies. Oxford [66] divides linguistic strategies into direct and indirect strategies, while O'Malley and Chamot [67] divide learning strategies into metacognitive strategies, cognitive strategies, and social-affective strategies. Gardner [68] mainly discusses the social psychological factors (especially attitude and motivation). He distinguishes integrative motivation from instrumental motivation. The rest of the works in this cluster look at various learner individual strategies that affect second language acquisition. Based on the above analysis, we propose that this cluster represents *SLA Studies of Learner Strategies*.

3.2.5. Cluster # 4

As shown in Table 1, the 5th largest cluster (#4) has 11 members and a silhouette value of 0.96. The mean publishing year of the 11 works is 2009, and other detailed information of the works is listed in Table 6 with the top 3 most frequently cited works highlighted.

Table 6. The Members of Cluster #4.

ClusterID	Author	Year	Source	Freq.
4	Ortega L	2009	Understanding second language acquisition	56
4	Paradis M	2009	Declarative procedural determinants of second languages	54
4	Norris JM	2009	Applied linguistics	78
4	Skehan P	2009	Applied linguistics	65
4	Lyster R	2010	Studies in second language acquisition	86
4	Hopp H	2010	Lingua	68
4	Abrahamsson N	2009	Language learning	90
4	Li SF	2010	Language learning	85
4	Spada N	2010	Language learning	78
4	Larson-hall J	2010	A guide to doing statistics in second language research using SPSS and R	63
4	Sorace A	2011	Linguistic approaches to bilingualism	69

Works in this cluster are mainly journal articles that report on the results of empirical studies. Based on a large scale study of Spanish/Swedish bilingual adults, Abrahamsson and Hyltenstam [69] argue that it is unlikely that adult learners of L2 will attain native-like fluency.

Lyster and Saito [70] reported on the effectiveness of oral corrective feedback (CF) based on a meta-analysis of 827 students. Li [71] reported on the effectiveness of corrective feedback in SLA based on a meta-analysis of 22 published studies and 11 Ph.D. dissertations. Both studies found that CF had a significant effect on L2 learners. In addition, works in this cluster also address the effects of grammatical complexity on learner language accuracy and fluency [72,73]. Therefore, we propose *Teaching Approaches to Complex Tasks* as the label for Cluster #4.

3.2.6. Cluster #5

As shown in Table 1, the 6th largest cluster (#5) has 10 members and a silhouette value of 0.947. The mean publishing year of the 10 works is 2007, and other detailed information of the works is listed in Table 7 with the top 3 most frequently cited works highlighted.

Table 7. The Members of Cluster #5.

ClusterID	Author	Year	Source	Freq.
5	Dörnyei Z	2001	Teaching and researching: motivation	29
5	Ellis R	2008	The study of second language acquisition	106
5	Dörnyei Z	2009	Second language acquisition	125
5	Taguchi T	2009	Second language acquisition	67
5	Dörnyei Z	2007	Research methods applied linguistics	60
5	Cameron L	2008	Complex systems and applied linguistics	60
5	Dörnyei Z	2009	Second language acquisition	65
5	Dörnyei Z	2005	The psychology of the language learner	136
5	Dörnyei Z	2009	The psychology of second language acquisition	59
5	Dörnyei Z	2011	Teaching and researching: motivation	85

Dörnyei's two works [74,75] review learner variables that affect SLA learning from the perspectives of other fields, such as psychology and sociology. The factors include personality, temperament, emotion, ability, motivation, style, strategy, anxiety, creativity, willingness to communicate, self-esteem and conviction. Ellis's book [76] takes a variety of perspectives, including cognitive, linguistic, sociocultural, and neurolinguistic to look at SLA development since the 1960s, and its coverage includes learner language, linguistic environment and social context, internal mechanisms, learner differences, and SLA instruction. The rest of the works in this cluster predominantly focus on the psychology of the language learner in second-language learning [77–80]. Therefore, we propose that this cluster represents *Psychology studies in SLA*.

3.2.7. Cluster #6

As shown in Table 1, the 7th largest cluster (#6) has 5 members and a silhouette value of 0.973. The mean publishing year of the 5 works is 2003, and the detailed information of the works is listed in Table 8 with the top 3 most frequently cited works highlighted.

Table 8. The Members of Cluster #6.

ClusterID	Author	Year	Source	Freq.
6	Dekeyser R	2003	The handbook of second language acquisition	29
6	Paradis M	2004	A neurolinguistic theory of bilingualism	29
6	Hyltenstam K	2003	The handbook of second language acquisition	30
6	White L	2003	Second language acquisition	54
6	Clahsen H	2006	Applied psycholinguistics	46

In this cluster, White's work [58] is a textbook for researchers that provides an overview and analysis of current SLA research conducted within the Chomsky's [17] generative linguistic framework and UG. She argues that SLA is constrained by principles and parameters. Using experimental

psycholinguistic techniques, Clahsen [81] investigates grammatical processing in language learners and explains how grammatical processing in language learners differs from that of native speakers. Hyltenstam and Abrahamsson's *The handbook of second language acquisition* [82] discusses maturational constraints on SLA based on some of the most important SLA hypotheses such as Critical Period Hypothesis, the Completeness Hypothesis, the Competition Hypothesis, the Fundamental Difference Hypothesis and the Input Hypothesis. It appears that none of the cluster labels *discrete stage* or *evidence* suggested by LLR or LSI algorithm is appropriate. Therefore, we propose *Linguistic and psycholinguistic approaches* as the label for this cluster.

3.2.8. Cluster #7

As shown in Table 1, The 8th largest cluster (#7) has 3 members and a silhouette value of 1. The mean publishing year of the 3 works is 2002, and the detailed information of the works is listed in Table 9.

Table 9. The Members of Cluster #7.

ClusterID	Author	Year	Source	Freq.
7	Wray A	2002	Formulaic language in computer-supported communication:	34
7	Ellis NC	2002	Studies in second language acquisition	55
7	Tomasello M	2003	Constructing a language	50

There are only 3 works in this cluster, and the most frequently cited work is N. Ellis's article [83] that takes an applied linguistic approach to discuss the input frequency of phonology, phonotactics, reading, spelling, lexis, morphosyntax, formulaic language, language comprehension, grammaticality, sentence production, and syntax. Tomasello [84] is focused on the usage-based theory of child language acquisition that develops from cognitive science, linguistics, and developmental psychology. It provides a competing theory against Chomskian generative grammar. Wray [85] develops a new computer-supported language processing system, TALK, to promote conversational fluency in non-speaking individuals. The cluster label *Usage-based approaches* suggested by LLR algorithm appears quite appropriate.

3.2.9. Cluster #8

As shown in Table 1, the 9th largest cluster (#8) has 3 members and a silhouette value of 0.925. The mean publishing year of the 3 works is 1993, and the detailed information of the works is listed in Table 10.

Table 10. The Members of Cluster #8.

ClusterID	Author	Year	Source	Freq.
8	Omaggio HA	1993	Teaching language in context	17
8	Lee J	1995	Making communicative language teaching happen	18
8	Horwitz EK	1991	Language anxiety	15

Lee and VanPatten's book [86] is basically a textbook for graduate teaching assistants and undergraduate teacher education majors. It provides a guideline for developing classroom environments to accommodate various listening, speaking, reading, and writing instructions. Omaggio [87] talks about teaching language in context. It is also a reference book for language instructors. Horwitz and Young's book [88] covers a number of areas of language acquisition, among which language anxiety emerges as one of the most important issues that institutions have to respond to. Therefore, the label *Collaborative teaching* suggested by the LLR algorithm represents the content of this cluster.

3.2.10. Cluster #9

As shown in Table 1, the 10th largest cluster (#9) has 3 members and a silhouette value of 1. The mean publishing year of the 3 works is 2009, and the detailed information of the works is listed in Table 11.

Table 11. The Members of Cluster #9.

ClusterID	Author	Year	Source	Freq.
9	Schmitt N	2008	Language teaching research	61
9	Grabe W	2009	Cambridge applied linguistics	73
9	Schmitt N	2010	Research and practice in applied linguistics	66

The cluster label of *reading comprehension* for this cluster by LLR algorithm is acceptable since reading is the common topic in the 3 works contained within this cluster. However, a label of *Reading and vocabulary* is recommended after a close examination of the 3 works. Grabe [89] provides a critical discussion on a wide range of reading theories, such as implicit and explicit learning, attention, noticing, consciousness, and contextual and background knowledge in reading comprehension. Schmitt's book [90] provides an overview of a wide range of vocabulary research methodologies including discussions on validity and reliability of research on vocabulary as well as resources available such as lexical test papers, corpora, software, and testing websites. Schmitt [91] overviews current research on vocabulary learning and proposes word families for reading and oral discourse. Obviously, CiteSpace's LLR algorithm has not captured vocabulary when generating the cluster label.

3.2.11. Cluster #10

As shown in Table 1, the 11th largest cluster (#10) also has 3 members and a silhouette value of 1. The mean publishing year of the 3 works is 1994, and other detailed information of the works is listed in Table 12.

Table 12. The Members of Cluster # 10.

ClusterID	Author	Year	Source	Freq.
10	Dörnyei Z	1994	Modern language journal	20
10	Oxford R	1994	Modern language journal	18
10	Clement R	1994	Language learning	15

Dörnyei [92] maintained that motivation is the main determinant of L2 learning achievement. This study investigates the nature and role of motivation in the L2 learning through an experiment. Oxford and Shearin [93] suggested several ways to extend learning motivation based on Gardner's [68] motivational theories. Applying social-psychological constructs, Clément, Dörnyei, and Noels [94] found that L2 student attitude, anxiety, and motivation toward learning English are associated with achievement. As all these works are related with motivation, the cluster is therefore labeled as *Motivation in SLA*.

To better visualize the origin, historical development, and current status of SLA knowledge clusters, we also performed a visual timeline analysis on the co-citation clusters of cited references as shown in Figure 4.

The map in Figure 4 is a little different from that located in Figure 3. This map shows the time span of each cluster, which bears some important research implications. It is obvious that Clusters #4, #5, and #9 are research areas that have emerged most recently. Particularly, we could expect that research topics within Clusters #4 and #5 will continue to receive attention for some time in the future.

Figure 4 also shows that the research priority in SLA keeps changing over time. In the earlier part of 1987–2003 (Clusters #1 and #3), researchers were mainly interested in theoretical SLA studies and their applications as well as learner strategies in SLA; then some researchers changed to focus on cognitive SLA studies about classroom teaching, collaborative teaching, and motivation in SLA

(Clusters #0, #8 and #10). From 2003 to 2010, the research interests in SLA shifted to working methods of SLA teaching and learning, linguistic and psycholinguistic approaches, and usage-based approaches (Clusters #2, #6, and #7). In most recent years, teaching approaches to complex tasks, psychology studies in SLA, and reading and vocabulary (Clusters #4, #5, and #9) were the most attractive research themes.

The nodes in the map are important indicators. Each node represents one cited reference, which is depicted with a series of tree-rings across multiple time slices. The area of each node is proportional to the total co-citation frequency of the associated reference. Table 13 lists the top 10 most frequently cited references. Except for Lantolf [95], all of the most frequently cited references fall into Clusters #4 and #5. This indicates that Clusters #4 and #5 are the most active research areas containing works that are cited most frequently.

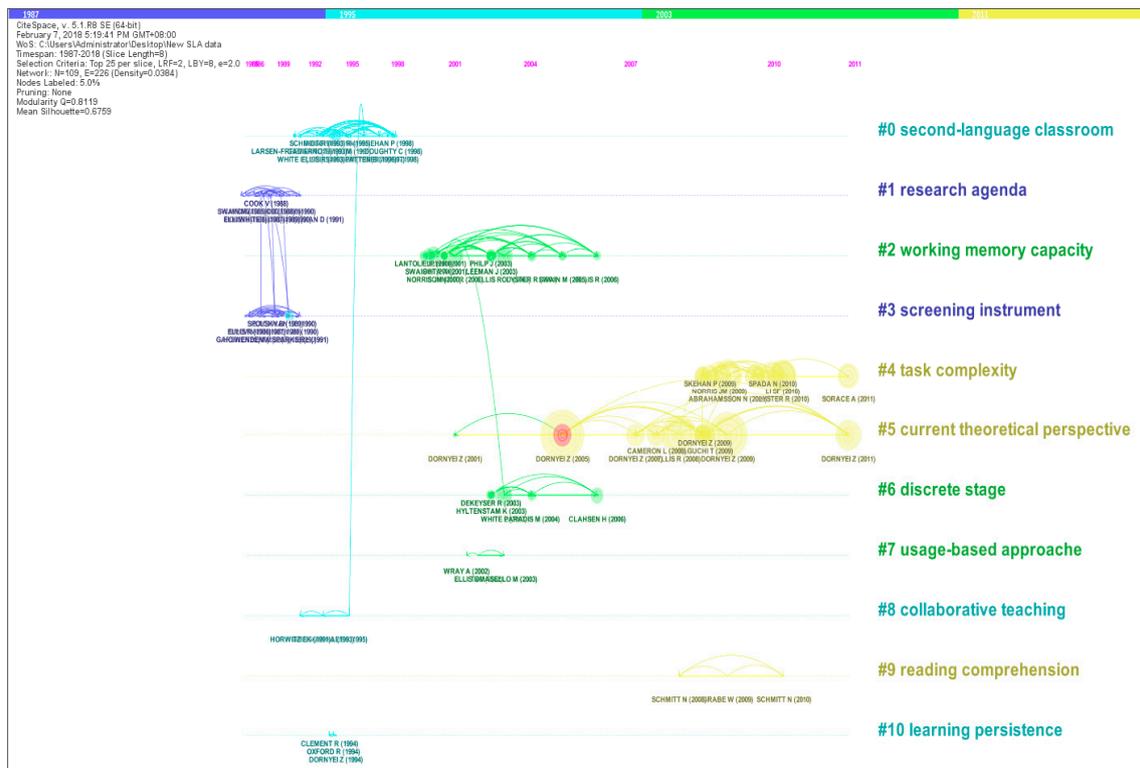


Figure 4. The timeline view of major research areas in SLA (1987–2018).

Table 13. The top 10 most frequently cited references.

Citation Counts	References	Cluster #
136	Dörnyei Z, 2005, The psychology of the language learner, 0, 0	5
125	Dörnyei Z, 2009, The psychology of second language acquisition, 0, 9	5
112	Lantolf J, 2006, sociocultural theory, 0, 0	15
106	Ellis R, 2008, The study of second language acquisition, 0, 0	5
90	Abrahamsson N, 2009, Language learning, 59, 249	4
87	Lyster R, 2010, Studies in second language acquisition, 32, 265	4
86	Li SF, 2010, Language learning, 60, 309	4
85	Dörnyei Z, 2011, Teaching and research: motivation, 0, 0	5
78	Norris JM, 2009, Applied linguistics, 30, 555	4
78	Spada N, 2010, Language learning, 60, 263	4

So far, we have examined the largest 11 clusters of the co-citation analysis, which represent the 11 major research areas in SLA between 1987 and 2018. Since all articles included in the database are

retrieved from top-tier journals indexed by WoS databases, the quality of their references is expected to be sound. As a result, the information obtained from this analysis will be reliable. For example, the citation frequencies of key references reflect their relative importance and contributions to SLA research. The identification of these articles, therefore, can guide researchers, particularly Ph.D. students, to quickly grasp the most valuable works available in the field.

3.3. Pivotal Works in SLA

To identify pivotal literature in a research field is crucial for a researcher to understand the theoretical underpinning of a new research article and its connections with other fields of study with which the research may not be familiar. Pivotal literature is measured by the Centrality values of references produced along with the network map during a co-citation analysis in CiteSpace. Centrality values are normalized to the unit interval of [0, 1]. A node of high centrality is usually one that connects two or more large groups of nodes. In general, a reference with a Centrality value equal to or greater than 0.1 can be considered a key study [47]. Key studies are shown in a cluster network as a purple circle. A thicker circle indicates a higher Centrality value.

Table 14 specifies the top 10 key articles in the literature in the SLA knowledge map. The top-ranked items by Centrality values are Dörnyei [75] in Cluster #5, with a Centrality of 0.03 and Pica [96] in Cluster #1, with a Centrality of 0.03. The Centrality values of the remaining 8 references are all 0.02. As a result, there are no purple circles in Figure 4. The results indicate that there may be a lack of pivotal studies in SLA. Although Chen's specification of a Centrality value of 0.1 as the threshold for key studies is based on his experience of analyzing data from biological or medicine fields [47], this value has worked well for studies using data from various disciplines [97–99]. The dataset of this study is even larger than some studies that produce pivotal works successfully. Therefore, the low Centrality values for all works in this study are not due to our data size. It more likely reflects the true situation facing SLA studies, and it echoes Gass's concern that to become a discipline integrated into the academic community SLA studies must be "needed" by other disciplines [48]. In fact, SLA is relatively a specific and narrow research field compared with some broader research fields. Therefore, it is quite natural for SLA researchers to cite and apply theories and practices from those general fields rather than the other way around. This may explain the lack of pivotal works with high Centrality values in this study.

Table 14. The pivotal works in second language acquisition.

Centrality	References	Cluster #
0.03	Dörnyei Z, 2009, The psychology of second language acquisition, 0, 0	5
0.03	Pica T, 1989, Studies in second language acquisition, 11, 63	1
0.02	White L, 2003, Second language acquisition and universal grammar, 0, 0	6
0.02	Oxford R, 1990, Language learning strategies, 0, 0	3
0.02	Omalley JM, 1990, Learning strategies, 0, 0	3
0.02	Chaudron C, 1988, Second language classroom, 0, 0	1
0.02	Carroll S, 2001, Input evidence, 0, 0	2
0.02	Long M, 1998, Focus on form in the classroom, 0, 15	0
0.02	Vanpatten B, 1996, Input processing and grammar instruction in second language acquisition, 0, 0	0
0.02	Larsen-freeman D, 1991, An introduction to second language acquisition research, 0, 0	1

3.4. Emerging Trends in SLA

In addition to generating network maps, CiteSpace can also reveal the frontiers and research trends in different periods. It uses an algorithm called Burst Detection to detect sudden growths in research interest to a particular work when its citation count increases abruptly. Compared with general frequency counts related to other works, the burst detection in CiteSpace can identify research frontiers more accurately [45].

Table 15 shows a ranked list of articles with their highest citation bursts taken together with their impact durations as based on the networks in Figure 3. The impact durations are indicated by blue

and red lines in the column titled “1987–2018”. The duration in which no bursts have been detected is depicted as a blue line, and the period during which a citation burst (CB) has been detected is shown as a red line. The start and end of a CB are also provided under the “Begin” and “End” columns. The table only shows 5 works that are experiencing sudden growth of citations towards 2018; works with CBs that have already ended can be found in Appendix A.

Table 15. The recent citation bursts.

References	Year	Strength	Begin	End	1987–2018
Hopp H, 2010, <i>Lingua</i> , v120, p901, doi:10.1016/2FJ.LINGUA.2009.06.004	2010	13.2455	2011	2018	
Norris JM, 2009, <i>Applied linguistics</i> , v30, p555, doi:10.1093/2FAPPLIN/2FAMP044	2009	15.2459	2011	2018	
Garcia O, 2009, <i>Bilingual and multilingual education in the 21st century</i> v0, p0	2009	12.2491	2011	2018	
Abrahamsson N, 2009, <i>Language learning</i> , v59, p249, doi: 10.1111/2FJ.1467-9922.2009.00507.X	2009	17.6663	2011	2018	
Paradis M, 2009, <i>Declarative and procedural determinants of second languages</i> , v0, p0	2009	10.4661	2011	2018	

Among the works having CB detected, Abrahamsson and Hyltenstam’s paper [69], titled *Age of Onset and Nativelikeness in a Second Language: Listener Perception Versus Linguistic Scrutiny*, has the strongest CB strength (17.6663), followed by Norris and Ortega’s paper [72], titled *Towards an Organic Approach to Investigating CAF in Instructed SLA: The Case of Complexity* (15.2459). “Ultimate attainment in L2 inflection: Performance similarities between non-native and native speakers” [100] ranks 3rd for CB strength (13.2445), while García’s *Bilingual and Multilingual Education in the 21st Century* [101] ranks 4th (12.2491), followed by Paradis [102] ranking 5th (10.4661).

Contrary to Abrahamsson and Hyltenstam’s argument that it is unlikely for adult L2 learners to attain native-like fluency [69], Hopp reports four experiments to test whether L2 inflection problems in L2 learners persist or they are a consequence of age-related grammatical impairment of L2 morphosyntax [100]. The study finds that native-like and ultimate attainment of L2 inflection is possible. It appears that nativelikeness is still the ultimate goal for many learners, which attracts continuous exploration from SLA researchers. The measurement of complexity, accuracy, and fluency (CAF) covered in Norris and Ortega’s paper [72] is related to automatic oral language generation. Its high CB strength indicates that a growing number of researchers are becoming optimistic about the future of automatic language generation, probably as a result of the fast development of computers, the Internet, and artificial intelligence (AI) technology. García’s book [101] addresses a number of global and local concerns in the 21st century such as bilingualism, bilingual education (both theories and practices), and international bilingual education policies with a focus on US and EU language policies in education. Paradis [102] provides critical views on neurolinguistic aspects of bilingualism. It examines the roles played by declarative and procedural memory to the L2 processing mechanism. Its high CB strength indicates that the application of neurolinguistics in SLA is receiving increasing attention. This is also a developmental direction for SLA that has been expected for some time [5,8].

Based on the outcomes above, we have identified the current research frontiers in SLA as bilingualism studies, automatic language generation including AI and computer-aided learning, language policies regarding SLA, and neurolinguistics. Among these research frontiers, bilingualism studies and language policies appear more global than local SLA-specific issues as they are also found as the topics experiencing a significant increase of interest in the field of applied linguistics [41]. The finding of neurolinguistics being another research frontier in this study also supports Lei and Liu’s [41] findings that interest in the topic of eye-tracking has risen significantly during 2013–2016

as eye-tracking is one of the most important neurolinguistic research methods. Automatic language generation had not been captured by previous studies as a research topic receiving significant attention [30,41]. However, its identification as a research frontier in this study is not surprising since AI has enjoyed a huge popularity in recent years, particularly after the media exposure of Google's Alpha Go. In addition, since the time slice of this study was set to 8 years (2011–2018), it is likely that its citation number only burst in more recent years. In sum, the identification of these frontiers is based on the CB strength, and continuous attention is still needed in order to watch whether these frontiers will actually develop into research areas in the future. It is worth noting that works not listed in Table 15 may also have the potential to become research frontiers in SLA. As rightly pointed out by an anonymous reviewer, it usually takes at least two years for a publication to receive a meaningful number of citations. Therefore, works with a high CB value during 2011–2018 would be different if similar studies were carried out in the future.

Between 1987 and 2018, a total of 34 strong CBs have been detected, as shown in Appendix A, with their cluster numbers shown in Appendix C. The top-ranked item by burst strength is Lantolf J [95] in Cluster #15 (35.29) followed by Nation ISP [103] in Cluster #14 (29.68), Schmidt R [59] in Cluster #2 (27.31), Ellis R [9] in Cluster #0 (23.67), Ellis N [83] in Cluster #7 (22.83), Tomasello M [84] in Cluster #7 (21.19), and Oxford R [66] in Cluster #3 (20.53). All these works have experienced stronger CBs than those listed in Table 15 have. Although the former is no longer seen as leading research frontiers with the end of their CBs, these important works are still frequently cited when conducting SLA research.

3.5. Important SLA Keywords

To further explore the key research topics in SLA during 1987 and 2018, co-occurring analyses were performed using keywords in our dataset utilizing CiteSpace. We set the time partition at 8 years and the top 25 most frequently cited articles were selected in each time period. Figure 5 shows the timeline view of co-cited keywords, which puts keywords in order from left to right according to their years of publication. The left-sided ones are “old” ones, and the right-sided ones are “young” more recent ones.

In the early years, SLA research has scrutinized general concepts such as English, children's language, instruction, foreign language, comprehension, target language, native language, etc. Instead, it focuses on more specific aspects such as discourse, perception, context, and knowledge. Research topics in more recent years focus on education, motivation, proficiency, and vocabulary. Keywords *significant difference*, *control group*, and *experimental group*, located near the bottom of the figure highlight the strong experimental tradition in SLA research. All the keywords projected in Figure 5 are yellow, green, or brown (a mixture of green and yellow). This means that major keywords have been used consistently over the past 30 years. In other words, keywords used together frequently 30 years ago are still being used together by researchers in recent works.

Just as CBs may be detected for an individual piece of research work, bursts of keyword counts can also be detected [45]. Table 16 lists the top 20 keywords from the dataset with the strongest bursts in SLA research between 1987 and 2018.

Table 16. The top 20 burst keywords.

Freq	Burst	Keyword
119	47.54	target language
110	43.92	second language learner
110	42.79	speech
85	40.52	context
78	36.7	discourse
77	36.23	literacy
277	31.05	experimental group

Table 16. Cont.

Freq	Burst	Keyword
390	25.96	control group
317	22.79	education
34	21.18	native language
28	17.43	word
27	16.81	input
26	16.19	model
290	13.78	proficiency
17	11.4	English
15	10.06	children
13	8.72	speech
12	8.05	student
746	6.91	native speaker
10	6.73	strategy
10	6.73	comprehension

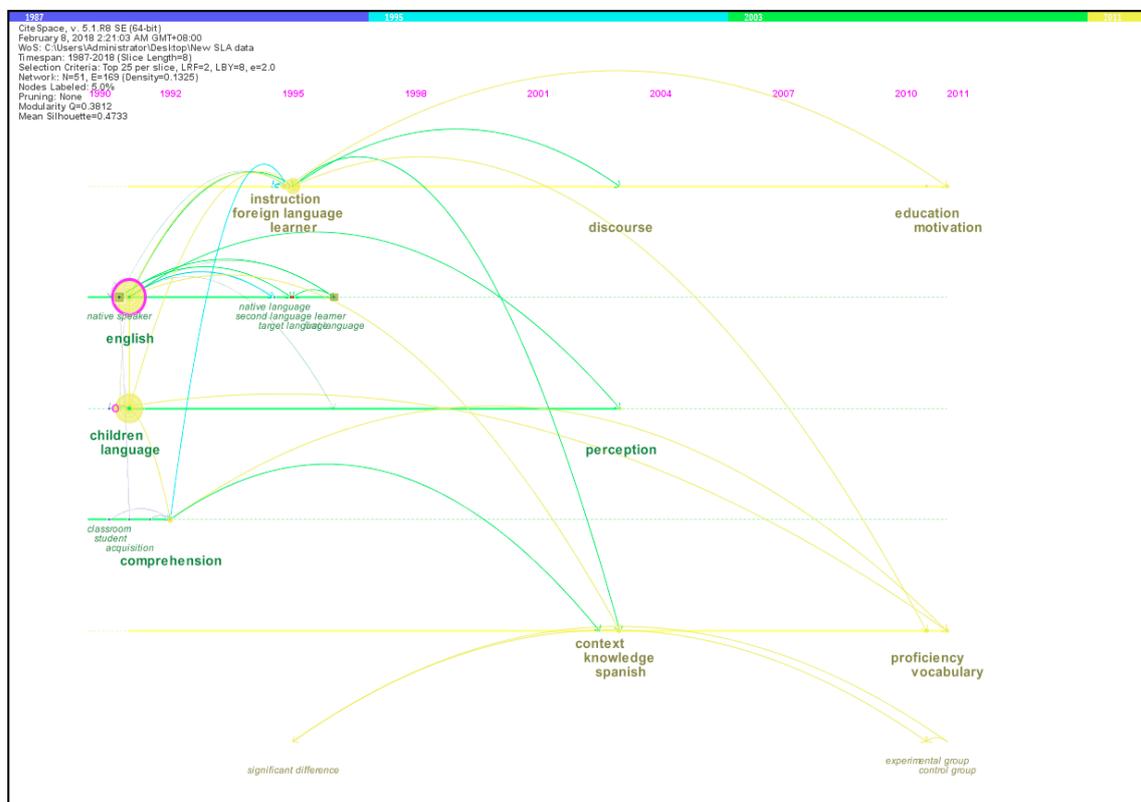


Figure 5. The timeline view of the keyword co-occurrence network (1987–2018).

The keywords appearing in this list are invaluable since they have been strongly focused on by various academics and have been expected to continuously provide insight into the development of new research areas within SLA studies. Furthermore, keywords outperform theories in disseminating new ideas and concepts and are mandated by all journals. Providing consistent keywords will benefit the overall communication and education in SLA research.

4. Conclusions

In this study, a critical review of SLA literature since 1987 has been carried out in a way that differs from traditional literature reviews. Driven by bibliometric big data, a review at the disciplinary

level becomes possible, and the results of this overarching review have helped to clarify some issues that have been under debate for a long time (i.e., whether SLA is an integrated discipline and, what can be done to facilitate the discipline's integration into academic community).

Eleven major research areas in the discipline have also been identified, and they are visually presented with a clear timeline of information that provides a more effective guide for the potential reader. The visualization technique and CiteSpace software used in this study produce high-quality clustering maps with clear structures and sound explanatory power. The labels of the research areas have subsequently been subjected to manual scrutiny and refinement to ensure the objectivity of the results. A pivotal analysis of the reference data has shown a serious shortage of pivotal studies in SLA, which may contribute to the difficulties facing SLA discipline in its integration into a broader academic research landscape. In addition, a citation burst analysis may reveal the contemporary research frontiers in SLA available to subsequent inspection.

Although this data-driven review has achieved its research objectives, it should be pointed out that, like any bibliometric studies, this study also suffers from some limitations. First, despite careful manual examination, there may be missing information in our dataset. This study used a keyword search to collect SLA publications in the WoS database. This may lead to some articles being left out if the author did not use those terms in the article's title, abstract or author-provided keywords. A better practice is to search all articles in all SLA related journals indexed in the WoS database, as done in a recent bibliometric study of applied linguistics [41]. Second, as found in a number of studies, automated search results are not error-free [104–106]. Although this study has refined the search results to “linguistics or education educational research or language linguistics” categories, some erroneous entries may still exist within the dataset. In addition, the fast update of WoS databases requires the researcher to synchronize the dataset regularly, and during the synchronizing process, some duplicates may be generated. Another limitation relates to the selection of a time span of the WoS dataset in the co-citation analysis. As pointed out by an anonymous reviewer, it would be methodologically more appropriate to only include bibliometric data from at least the two years prior to the study when conducting co-citation analysis. Despite the above-mentioned limitations, this study has provided a new perspective on the development of SLS. Future studies looking at longer timespans are also strongly encouraged.

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Appendix A. The top 34 References with the Strongest Citation Bursts

References	Year	Strength	Begin	End
Chomsky N, 1986, Knowledge Language, V0, P0	1986	5.6861	1987	1994
Horwitz EK, 1986, Modern language journal, v70, p125, doi:10.2307/2F327317	1986	6.323	1988	1994
Omalley JM, 1990, Learning strategies, v0, p0	1990	13.8658	1991	1998
Oxford R, 1990, Language learning strategies, v0, p0	1990	20.5332	1992	1998
Flege JE, 1995, The journal of the acoustical society of America, v97, p3125, doi:10.1121/2F1.413041	1995	8.7961	1995	2002
Oxford R, 1994, Modern language journal, v78, p12, doi:10.2307/2F329249	1994	9.9032	1995	2002
Kramsch C, 1993, Context and culture in language teaching, v0, p0	1993	9.0572	1995	2001
Ellis R, 1993, Tesol quarterly, v27, p91, doi:10.2307/2F3586953	1993	7.919	1995	2001
Spade N, 1993, Studies in second language acquisition, v15, p205, doi:10.1017/2FS0272263100011967	1993	7.3505	1995	2001
Schmidt R, 1993, Annual review of applied linguistics, v13, p206, doi:10.1017/2FS0267190500002476	1993	7.3505	1995	2001

References	Year	Strength	Begin	End
Tomlin RS, 1994, Studies in second language acquisition, v16, p183, doi:10.1017/2FS0272263100012870	1994	7.6907	1995	2002
Cadierno T, 1993, Studies in second language acquisition, v15, p225, doi:10.1017/2FS0272263100011979	1993	7.3505	1995	2001
Pica T, 1994, Language learning, v44, p493, doi: 10.1111/2FJ.1467-1770.1994.TB01115.X	1994	13.7913	1995	2002
Dornyei Z, 1994, Modern language journal, v78, p273, doi:10.2307/2F330107	1994	11.0119	1995	2002
Peirce BN, 1995, Tesol quarterly, v29, p9, doi:10.2307/2F3587803	1995	7.2463	1996	2002
Ellis R, 1994, The study of second language acquisition, v0, p0	1994	23.6734	1996	2002
Ellis R, 2001, Language learning, v51, p1, doi:10.1111/2FJ.1467-1770.2001.TB00013.X	2001	13.7322	2003	2009
Schmidt R, 2001, Cognition and second language instruction, v0, pp3, doi:10.1017/2FCB09781139524780.003/5D	2001	27.3078	2003	2009
Nicholas H, 2001, Language learning, v51, p719, doi:10.1111/2F0023-8333.00172	2001	13.2694	2003	2009
Nation ISP, 2001, Learning vocabulary, v0, p0	2001	29.6791	2003	2009
Dornyei Z, 2001, Teaching and research: motivation, v0, p0	2001	13.2694	2003	2009
Wray A, 2002, Formulaic language I, v0, p0	2002	14.0019	2003	2010
Ohta A, 2001, Second language acquisition, v0, p0	2001	13.7322	2003	2009
Carroll S, 2001, Input evidence, v0, p0	2001	13.2694	2003	2009
Ellis NC, 2002, Studies in second language acquisition, v24, p143, doi:10.1017/2FS0272263102002024	2002	22.8313	2003	2010
Philp J, 2003, Studies in second language acquisition, v25, p99, doi:10.1017/2FS0272263103000044	2003	16.0318	2004	2010
Leeman J, 2003, Studies in second language acquisition, v25, p37, doi:10.1017/2FS0272263103000020	2003	16.4599	2004	2010
Tomasello M, 2003, Constructing a language, v0, p0	2003	21.1909	2004	2010
Lantolf J, 2006, Sociocultural theory, v0, p0	2006	35.2871	2008	2014
Hopp H, 2010, Lingua, v120, p901, doi: 10.1016/2FJ.LINGUA.2009.06.004	2010	13.2445	2011	2018
Norris JM, 2009, Applied linguistics, v30, p555, doi: 10.1093/2FAPPLIN/2FAMP044	2009	15.2459	2011	2018
Garcia O, 2009, Bilingual education in the 21 century, v0, p0	2009	12.2491	2011	2018
Abrahamsson N, 2009, Language learning, v59, p249, doi:10.1111/2FJ.1467-9922.2009.00507.X	2009	17.6663	2011	2018
Paradis M, 2009, Declarative procedural determinants of second languages, v0, p0	2009	10.4661	2011	2018

Appendix B. The Details of the Largest 11 Clusters

ClusterID	Size	Silhouette	Mean (Year)	Label (LSI)	Label (LLR)	Label (MI)
0	19	0.917	1994	second language; production; comprehensible output; separation; classroom; interference; standardized varieties; foreign language; standards; reading goals;	second-language classroom; teacher-learner interaction; learner-centered classroom; sociocultural perspective; non-native speakers production; comprehensible output; second language; working memory capacity; current theoretical perspective	arts-based creativity ; l2 collocation; dialect acquisition; using video; foreign language; summer study; foreign culture ; learning persistence; private speech; efl learner; l1 influence
1	14	0.936	1987	input; research; original definition; current views; order; motivation; research agenda; 2nd language classroom; elementary foreign-language classroom; floor griffiths; disembedding disembedded figures;	research agenda ; l2 acquisition ; task-based approach; working memory capacity ; current theoretical perspective; learning motivation; heritage language acquisition; current issue; oral feedback; classroom sla;	working memory capacity ; current theoretical perspective; learning motivation; heritage language acquisition; current issue; oral feedback; classroom sla; second-language classroom; teacher-learner interaction; learner-centered classroom;

ClusterID	Size	Silhouette	Mean (Year)	Label (LSI)	Label (LLR)	Label (MI)
2	14	0.943	2002	effects; acquisition; inductive instruction; direct object pronouns; German; output hypothesis; language awareness; focus; proficiency; output second language;	working memory capacity; oral feedback; classroom sla; language awareness; language development; ten-month investigation; corrective feedback; heritage language acquisition; current issue; adult esl classroom	arts-based creativity; l2 collocation; dialect acquisition; using video; foreign language; summer study; foreign culture); learning persistence; private speech; efl learner
3	12	0.916	1988	disembedding disembedded figures; griffiths; appraisal; field-dependence independence; sheen reappraisal; landscape; l2 research; foreign-language instruction; foreign-language learning-problems; 2nd-language acquisition research listening proficiency; efl lecture learning;	screening instrument; foreign-language learning-problem; research agenda; 2nd-language acquisition research; field independence-dependence; working memory capacity; current theoretical perspective; learning motivation; heritage language acquisition; current issue	working memory capacity; current theoretical perspective; learning motivation; heritage language acquisition; current issue; oral feedback; classroom sla; second-language classroom; teacher-learner interaction; learner-centered classroom
4	11	0.96	2009	corrective feedback; fluency development; proceduralization; interaction; accuracy; quasi-experimental intervention studies; instruction; classroom-based study; outcome measure; morphological errors effects; mediator;	task complexity ; classroom-based study; l2 construction; individual difference; proficiency level; program type; discourse feature ; narrative writing performance ; left dislocation; nativelike right-dislocation;	arts-based creativity ; l2 collocation ; dialect acquisition ; using video ; foreign language ; summer study ; foreign culture ; learning persistence ; private speech ; efl learner ;
5	10	0.947	2007	language; self-concept; continuity; change; German; activity theory perspective; flow theory; modality; captioning videos; discipline willingness; second language;	current theoretical perspective; learning motivation; language-learning motivation; self-related belief; learning opportunities; unknown natural language; adult language; age effect ; cross-linguistic evidence ; second language acquisition;	summer study; affective outcome; mixed-methodology investigation; arts-based creativity; l2 collocation; dialect acquisition; using video; foreign language; foreign culture; learning persistence;
6	5	0.973	2003	evidence; wh-words; variable-dependent vulnerability; l2 acquisition; l2 Chinese grammars; existential polarity words; semantics-syntax interface; love; syntactic misanalysis; German role;	discrete stage ; brain potential ; l2 grammatical learning ; Spanish heritage speaker; adult second language learner; Spanish clitics; word order; heritage language acquisition; current issue; event-related potential study;	arts-based creativity; l2 collocation; dialect acquisition; using video; foreign language; summer study; foreign culture; learning persistence; private speech; efl learner;
7	3	1	2002	language; acquisition; foreign language class; hairless; new Spanish; modisms; method; result; interaction; cognitive neuroscience perspective development;	usage-based approach; second language; heritage language acquisition; current issue; l2 collocation; efl learner; l1 influence; acquiring English collocation; Japanese esl user; working memory capacity;	working memory capacity; usage-based approach; heritage language acquisition; current issue; current theoretical perspective; learning motivation; second language; oral feedback; classroom sla; l2 collocation;

ClusterID	Size	Silhouette	Mean (Year)	Label (LSI)	Label (LLR)	Label (MI)
8	3	0.925	1993	language; foreign language curriculum; culture; boundaries; implementing technology; effectiveness; speaking components; foreign language; evaluation study; foreign language anxiety effectiveness; reading;	collaborative teaching; beginning foreign language class; working memory capacity; current theoretical perspective; learning motivation; heritage language acquisition; current issue; oral feedback; classroom sla; second-language classroom; teacher-learner interaction; learner-centered classroom;	working memory capacity; current theoretical perspective; learning motivation; heritage language acquisition; current issue; oral feedback; classroom sla; second-language classroom; teacher-learner interaction; learner-centered classroom;
9	3	1	2009	Spanish schools; efl course books; vocabulary input; classroom materials; pedagogical sequencing; practice; students; teaching; research; university textbooks teaching;	reading comprehension; working memory capacity; current theoretical perspective; learning motivation; heritage language acquisition; current issue; oral feedback; classroom sla; second-language classroom; teacher-learner interaction;	working memory capacity; current theoretical perspective; learning motivation; heritage language acquisition; current issue; oral feedback; classroom sla; second-language classroom; teacher-learner interaction; learner-centered classroom;
10	3	1	1994	Semi-bilingual university students; immigrant backgrounds; learning persistence; students; language; analysis; intensity; Japanese; communicative style; perceptions;	learning persistence; semi-bilingual university student; working memory capacity; current theoretical perspective; learning motivation; heritage language acquisition; current issue; oral feedback; classroom sla; second-language classroom;	working memory capacity; current theoretical perspective; learning motivation; heritage language acquisition; current issue; oral feedback; classroom sla; second-language classroom; teacher-learner interaction; learner-centered classroom;

Appendix C. The Nodes in Each Cluster

ClusterID	Author	Year	Source	Freq.
0	Ellis R	1994	The study of second language acquisition	42
0	Tomlin RS	1994	Studies in second language acquisition	14
0	White L	1991	Second language research	15
0	Larsen-freeman D	1991	An introduction to second language acquisition research	14
0	Donato R	1994	Vygotskian approaches	18
0	Spade N	1993	Studies in second language acquisition	13
0	Swain M	1995	Principle and practice in second language acquisition	18
0	Aljaafreh A	1994	Modern language journal	13
0	Pica T	1994	Language learning	25
0	Vanpatten B	1996	Input processing and grammar instruction	15
0	Schmidt R	1995	Attention awareness	13
0	Swain M	1995	Applied linguistics	21
0	Schmidt R	1993	Annual review of applied linguistics	13
0	Ellis R	1993	Tesol quarterly	14
0	Cadierno T	1993	Studies in second language acquisition	13
0	Lyster R	1997	Studies in second language acquisition	15
0	Long M	1998	Focus on form in classroom	17
0	Skehan P	1998	A cognitive approach to language learning	14
0	Doughty C	1998	Focus on form in the classroom	16
1	Ellis R	1985	Understanding second language acquisition	9
1	Pica T	1987	Tesol quarterly	8
1	Swain M	1985	Input in second language acquisition	7
1	Doughty C	1986	Tesol quarterly	9
1	Chomsky N	1986	Knowledge of language	9
1	Cazden CB	1988	Classroom discourse	7
1	White L	1987	Applied linguistics	8
1	Cook V	1988	Chomsky's universal grammar	7
1	White L	1989	Universal grammar and second language acquisition	10
1	Pica T	1989	Studies in second language acquisition	10
1	Schmidt RW	1990	Applied linguistics	7
1	Chaudron C	1988	Second language classroom	21
1	Ellis R	1990	Instructed second language acquisition	11
1	Larsen-freeman D	1991	An introduction to second language acquisition research	11

ClusterID	Author	Year	Source	Freq.
2	Swain M	2000	Sociocultural theory and second language learning	41
2	Lantolf JP	2000	Sociocultural theory and second language learning	30
2	Norris JM	2000	Language learning	50
2	Carroll S	2001	Input evidence	29
2	Schmidt R	2001	Cognition and second language instruction	59
2	Ohta A	2001	Second language acquisition	30
2	Ellis Rod	2003	Task-based language learning and teaching	55
2	Ellis R	2001	Language learning	30
2	Nicholas H	2001	Language learning	29
2	Leeman J	2003	Studies in second language acquisition	39
2	Philp J	2003	Studies in second language acquisition	38
2	Lyster R	2004	Studies in second language acquisition	35
2	Ellis R	2006	The study of second language acquisition	30
2	Swain M	2005	Handbook of research in second language teaching and learning	29
3	Ellis R	1986	Understanding second language acquisition	7
3	Gardner R	1985	Social psychology and second language learning	11
3	Horwitz EK	1986	Modern language journal	10
3	Wenden A	1987	Learner strategies in language learning	8
3	Oxford R	1990	Language learning strategies	35
3	Brown HD	1987	Principles of language learning and teaching	7
3	Omalley JM	1990	Learning strategies	24
3	Sparks R	1989	Annal dyslexia	8
3	Spolsky B	1989	Conditions for 2nd language revitalization	7
3	Skehan P	1989	Individual differences in second language learning	7
3	Sparks RL	1991	Modern language journal	7
3	Bachman LF	1990	Fundamental considerations in language testing	7
4	Ortega L	2009	Understanding second language acquisition	56
4	Paradis M	2009	Declarative procedural determinants of second languages	54
4	Norris JM	2009	Applied linguistics	78
4	Skehan P	2009	Applied linguistics	65
4	Lyster R	2010	Studies in second language acquisition	86
4	Hopp H	2010	Lingua	68
4	Abrahamsson N	2009	Language learning	90
4	Li SF	2010	Language learning	85
4	Spada N	2010	Language learning	78
4	Larson-Hall J	2010	A guide to doing statistics in second language research using SPSS and R	63
4	Sorace A	2011	Linguistics approaches to bilingualism	69
5	Dornyei Z	2001	Teaching and research: motivation	29
5	Ellis R	2008	Study 2 language acquisition	106
5	Dornyei Z	2009	Second language acquisition	125
5	Taguchi T	2009	Second language acquisition	67
5	Dornyei Z	2007	Research methods in applied linguistics	60
5	Cameron L	2008	Complex systems and applied linguistics	60
5	Dornyei Z	2009	Second language acquisition	65
5	Dornyei Z	2005	The psychology of the language learner	136
5	Dornyei Z	2009	The psychology of second language acquisition	59
5	Dornyei Z	2011	Teaching and research: motivation	85
6	Dekeyser R	2003	The handbook of second language acquisition	29
6	Paradis M	2004	A neurolinguistic theory of bilingualism	29
6	Hyltenstam K	2003	The handbook of second language acquisition	30
6	White L	2003	Second language acquisition	54
6	Clahsen H	2006	Applied psycholinguistics	46
7	Wray A	2002	Formulaic language in computer-supported communication	34
7	Ellis NC	2002	Studies in second language acquisition	55
7	Tomasello M	2003	Constructing a language	50
8	Omaggio HA	1993	Teaching language in context	17
8	Lee J	1995	Making communicative language teaching happen	18
8	Horwitz EK	1991	Language anxiety	15
9	Schmitt N	2008	Language teaching research	61
9	Grabe W	2009	Cambridge applied linguistics	73
9	Schmitt N	2010	Research and practice in applied linguistics	66
10	Dornyei Z	1994	Modern language journal	20
10	Oxford R	1994	Modern language journal	18
10	Clement R	1994	Language learning	15
11	Garcia O	2009	Bilingual education in the 21 century	64

ClusterID	Author	Year	Source	Freq.
11	Coyle D	2010	Children content language	65
12	Flege JE	1995	Speech perception	13
12	Flege JE	1995	Journal of the acoustical society of America	16
13	Kramsch C	1993	Context and culture in language teaching	16
13	*Nat S	1996	Stand for foreign language learning	15
14	Nation ISP	2001	Learning vocabulary	64
15	Lantolf J	2006	Sociocultural theory	112
16	Chomsky N	1995	Minimalist program	13
17	Nat S	1999	Standards for foreign language learning	30
18	Omaggio AC	1986	Teaching language co	7
19	Peirce BN	1995	Tesol quarterly	13

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