A Social Network Analysis of Knowledge Infrastructure in the Second Language Acquisition Domain

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Jang, Haejin, Jacob Wood, and Gohar Feroz Khan. 2017. A Social Network Analysis of Knowledge Infrastructure in the Second Language Acquisition Domain. *Linguistic Research* 34(Special Edition), 125-160. This study utilizes the social network analysis (SNA) technique to analyze and better understand the semantic and knowledge networks that are associated with the linguistic domain of second language acquisition (SLA). Our analytic research helps to further define our understanding of SLA by constructing a detailed description of the domain's network knowledge infrastructure. By analyzing 5,297 publications, authored by 9,220 authors, and published in 1471 outlets. Our study utilized the SNA tool to examine the author, institution, bibliographic coupling and keyword networks of the SLA domain. The results of our study show that SLA network is relatively fragmented containing several isolated clusters of authors. The study also found that the diameter of the co-authorship network is relatively small and has clustering co-efficient that is high and displays the small world phenomenon. **(Konkuk University, Chungnam National University, University of Waikato Management School)**

Keywords Scientometrics, linguistics, second language acquisition, social network analysis

1. Introduction

The field of second language acquisition (SLA) is a highly complex and rapidly evolving field of scholastic endeavor. Language acquisition has also been described as the process through which humans acquire the capacity to enable them to perceive and comprehend language, as well as to produce and use words to communicate (Lantolf, et al., 2015; Al Hammadi, 2016). Moreover, SLA is the methodological process from which people learn a second language (L2). Scholars have approached the field of SLA from a wide range of backgrounds such as sociology, psychology, education, and

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linguistics to name but a few. Such a multitude of backgrounds has both positive and negative effects on the domain. The advantage is, by offering a multiplicity of perspectives, the SLA domain is provided with a richer more detailed perspective of language learning. However, on the other hand, a wide array of viewpoints crates confusion as scholars from the different fields are unable to reach agreement on important theoretical issues (Gass and Selinker, 2007). Areas of SLA have focused on behaviorist theory (Bloomfield, 1933), contrastive analysis (Lado, 1957; Schachter and Celce-Murcia; Schachter, 1974; Zobl, 1980), error analysis (Schachter, 1974; Schachter and Celce-Murcia, 1971), first language acquisition (Foster-Cohen, 1999), third language acquisition (Cenoz and Genesee, 1998), bilingual acquisition (Edwards, 2006, Bhatia, 2006), heritage language acquisition (Valdes, 2001, Carreira, 2002; Ke, 1998; Montrul, 2002, 2004; Polinsky, 1995, 2000, Gass and Lewis, 2007) child second language acquisition (Hoek Ingram, and Gibson, 1986; Cohen, 1999; Rocca, 2007; Hakukta, 1974a, 1974b; Rvem, 1968, 1974; Ravem, 1968, 1974) adult second language acquisition, and universal grammar (Chomsky, 1995; Farahani, et al., 2014), the influence of first language on the processing of L2 (Lee, 2016), developmental psycholinguistics (Chomsky 1962, Garman; 1990; Locke, 2009) and the role of age in second language acquisition (Schumann, 1986; Marshall, 1994; and Ochs and Schieffelin, 2001). The basic premise of these studies has been to assess how language is acquired through conventional means of assessment such as tests, interviews, questionnaires, literature reviews and empirical analyses using statistical tools.

This study takes a different approach to these traditional forms on inquiry by examining the knowledge infrastructure of the SLA domain. In order to do so we use the social network analysis (SNA) technique to provide a holistic analysis of the SLA field and in doing so allow us to reveal hidden structures of these knowledge networks. The SNA tool utilizes big data to document the network complexities of the domain, influential researchers, outlets (journal, conference papers etc), institutions, and countries; and emerging and fading trends within the SLA domain. By using the SNA technique we are able to not only measure, monitor, and evaluate the knowledge flows and relationships in a network (Serrat, 2009) but also identify the key players in SLA knowledge network and the structural holes at the network level that can be strategically filled to accelerate knowledge flows (Khan and Park, 2013).

In order to reveal these hidden structures, we search for and analyze publications included in the online Web of Science database. The knowledge infrastructure that is

recovered from this search documents the collaborative works of researchers, institutions, countries, and outlets that are dynamically engaged in helping shape, generate, distribute, and preserve the SLA domain's intellectual knowledge. The networks uncovered provide a visual interpretation of how collaborative relationships create new knowledge in the form of publications. In our study, these knowledge networks are investigated the author, institution, bibliographic coupling, and keyword levels.

The layout of this research study is organized as follows. Firstly, a summary of previous attempt to analyze SLA infrastructure is presented, this is followed by an in depth examination of the methodological processes adopted for this study. Finally, the main findings are discussed before a series of relevant conclusions are drawn.

2. A literature review

SLA a growing field which deals which has applications in a range of fields including the humanities, social sciences, and biology. From an empirical analysis perspective, the literature identified within the SLA domain covers a myriad of theoretical areas. For SLA, learners are influenced by their own native language (NL). This 'transfer' process forms a cornerstone of the SLA domain. In addition, the behaviorist theory of language and language learning has also proved to be a formative and influential area of SLA. In this instance, Bloomfield (1933) explains that language learning is a habitual act. Through stimulus-response connection we acquire linguistic skills and abilities. In the behaviorist field, learning represents an accumulation of various experiences and actions with SLA considered to be very much a habitual approach. Therefore, the role of native language is an important determining factor as to whether a second language learner will be successful in mastering the target language. From this, the issue of contrastive analysis has immerged as an important area scholastic enquiry. Contrastive analysis refers to an examination of the similarities and differences that exist between two languages. Lado (1957) analyzed the differences and similarities of L1 and L2 participants' speech characteristics, as well as their morphological, syntactic and cultural systems. Lado stated that learning becomes more difficult when significant differences exist between L1 and L2 participants. In other words, these differences can lead to more errors being made during the learning process. However, Zobl (1980) changed people's perspectives by comparing different results in French

learners of English and English learners of French. In French, the grammatical structure of the language sees the object comes before the verb, while in English the reverse is true with the object coming after the verb. In this instance, native English speakers had greater difficulty in learning the structure of French as its grammatical structure was opposite to their L1. However, as Zobl found native French speakers had no problem learning the structure of English even though there were grammatical differences. Given these findings, the credibility of the contrastive analysis theory was questioned giving rise to a new field of study. Known as error analysis, this new area sought to explain these aspects that contrastive analysis failed to adequately convey. Within the error analysis domain lie two different types of enquiry; inter-lingual and intra-lingual errors. In this instance, inter-lingual errors refer to those made by native speakers and intra-lingual errors as being those made by second language learners. Within the field of error analysis, respondents of different native languages have been found to make similar errors based around the intra-lingual error framework. However, Schachter (1974) provides an alternative argument, saying that it is not easy to pin point the source of the error, while, Schachter and Celce-Murcia (1971) state, in their experiment with Chinese learners of English, that as we are unable to delve into the minds of individual participants it is difficult to ascertain the source of the errors that they make. In addition, Ard and Homburg (1983) stated that language transfer plays a pivotal role in SLA. Their results showed that Spanish learners of English better understood the meaning of the words than Arabic learners of English as there were many similarities to vocabularies used in Spanish and English. Therefore, for a learning perspective, it is helpful when a native language (L1) and second language (L2) are similar to each other. In another area of enquiry, researchers also began to question why and when L1 transfer occurs. In this instance, Doughty (1991) conducted an experiment in which relative clauses would be taught using three teaching methods (meaning oriented, rule treatment, control). The results of the study showed that despite using different teaching methodologies the learning outcomes for the three groups of participants were very similar. Therefore, the ways in which a L1 influences the development of L2 in very complex and not easy to explain.

In terms of first language acquisition, children who enjoy a cognitively impaired linguistic system are able to acquire first language abilities in a way that allows them to interact with others and express themselves in ways that they want. While this may appear easy, it is in fact an amazing accomplishment that demonstrates the processes of

cognitive development. The journey of linguistic development starts as infants where young babies start formulating sounds as a result of both improving physical capabilities and exposure to the environment around them (Foster-Cohen, 1999). From around 20 months old these developments allow word formation to occur and where the process of further understanding the meaning of words begins to grow; albeit it at differing raters of learning. However, this acquisition process is by no means simple. In this instance, Hoek, Ingram, and Gibson (1986) found that one child's use of the world *bunny* is associated used to explain a myriad of other words such as *doll, hen, shoe, car, giraffe, cow, and bear* etc. Moreover, children often underuse words as well such as using *tree* as when it has leaves and not when the leaves fall off during Autumn. The developmental rules that are associated with SLA in children are not applicable in the case of adult learning. Child SLA refers to the acquisition of a second language by a child once they have developed native language abilities but before they reach what is defined as "a critical period"[1] in their developmental process (Cohen, 1999). If child SLA is achieved before this critical period, the individual can be considered bilingual. However, there is a great deal of controversy over how and when the period of child SLA starts and finishes. Rocca (2007) stated that child second language learners, like first language learners, showed morphological sensitivity unlike adult second language learners. While unlike first language learners, they were also influenced by language transfer like adult second language learners (Hakukta (1974a, 1974b), Ravem (1968, 1974). Chomsky (1995) comes up with the theory that children learn a complex set of abstractions due to the idea of Universal Grammar (UG). UG is innate universal language properties that motivates children to successfully acquire languages without sufficient input. In conjunction, with the notion of child SLA is the issue of bilingualism or multilingualism as it otherwise referred to. A broadly defined theory, bilingualism can be applied in many contexts. As Edwards (2006) argues, most people display bilingual traits with knowledge words from languages other than their own first language. While in contrast, Bhatia (2006) states that one only become bilingual at the conclusion of the SLA process. There are also varying forms of bilingualism. Early bilingualism relates to a situation in which a national language differs from the language an individual may use at home (Meisel, 1989). In this instance a child is exposed to a secondary language at school, where he uses it to communicate with friends and teachers who are unable to

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1   The critical period is flexible in its usage as it can refer to child aged across a range of ages (Cohen, 1999).

speak their own native language but continues to use his primary language at home (Meisel, 1989). In contrast, late bilingualism refers to the acquisition of a second language as an adult and is the result of a range of mechanisms that are different to early bilingualism (Butler and Hakuta, 2004).

In addition, the field of SLA encompasses the areas of heritage language acquisition and third language acquisition. Valdes (2001) states that Heritage language refers to historical and personal connection that one has to a specific language and as such forms an important part of the wider SLA domain. The acquisition characters of heritage learners differ from those of L2 learners of that particular language (Carreira, 2002; Ke, 1998; Montrul, 2002, 2004; Polinsky, 1995, 2000; Gass and Lewis, 2007). Finally, third Language Acquisition (TLA) is a new topic of research that has drawn the attention of many scholars during the last two decades (Hammarberg 2001, Cenoz 2001, De Angelis 2007, Bardel and Falk 2010). With a broad focus TLA has examined an array of different areas within the language acquisition process including formal linguistic (Rothman 2010), psycholinguistic (Cenoz 2001), sociolinguistic (Bhatia and Ritchie 2013), educational or applied perspectives (Cenoz, et al., 2001). In addition, there are a number of significant studies that emphasize the important role age plays in SLA (Schumann, 1986; Marshall, 1994; and Ochs and Schieffelin, 2001). Research has shown that the older we become, the more difficult it is for us to master a new language and become bilingual; that is, to develop the ability to use two languages at the same level of competency (Al Hammadi, 2016). Adults ($\geq$30 years of age) learning a second language face a number of additional challenges not faced by primary language learners. Bruner (1983) notes the process of learning a second language requires the memorization of rules, vocabulary and cognitive ability to apply these rules and express their thoughts effectively and understand others in a way that requires a lot more time and effort than when learning their own native language. In addition to this, there are also a range of social and cultural challenges, such as essential characteristics that are not prevalent in one's own culture that makes the language more difficult to understand and accept (Carlson, et al., 2007).

The acquisition of a secondary language is a detailed and extremely complex process that contrasts from that of other academic disciplines, in that knowledge and skills cannot be developed in relatively coherent manner; in SLA the appropriate use of abilities and understanding differs according to one's environment and as such requires constant training and practice in order to bring together the variability of applications.

3. Methodology

3.1 The use of Social Network Analysis

As a result of the information revolution and the emergence of greater flows of data, information, and knowledge, the use of social networks as a means of organizing human activity have become increasingly important. Social network analysis (SNA) endeavors to understand networks and their participants and has two primary focuses: the actors (node-level) and the relationships (network-level) that exist between them in a specific social context (Serrat, 2009). In this instance, social network research provides an essential means of understanding the way in which these actors interact and share knowledge.

The defining feature of SNA is its focus on the structure of relationships, ranging from casual acquaintance to close bonds. SNA assumes that relationships are important. It maps and measures formal and informal relationships to understand what facilitates or impedes the knowledge flows that bind interacting nodes together. SNA helps to document who know whom, and who shares what information and knowledge with whom (Serrat, 2009). The social network is based around a set of nodes which are connected by ties. Nodes are actors and traditionally include authors, institutions, outlets, countries; whereas the relations, or ties, connect the actors and can vary in content, direction, and relational strength, all of which influence the dynamics of the network (Garbon, et al., 1999).

By using the SNA technique we are able to identify which actors (authors, institutions etc.) that play central roles in the network. It is also able to reveal patterns and regularities in a manner which academics can work together to generate knowledge (Krystallis, et al., 2011). To date there have been a myriad of genres that have been analyzed using SNA. Some of these perspectives include IT management (Khan and Wood, 2015) international trade (Wood and Khan, 2015) accounting (Worrell, et al., 2013) medical science (Ma, et al., 2014) marketing (Maharani and Gozali, 2015) and employee engagement (Kim, et al., 2016). Our study builds on these previous SNA studies by documenting the semantic and knowledge networks that are associated with the linguistic SLA domain. In particular, in order to reveal both the way in which the SLA domain is defined and the hidden structures it may reveal, we have searched for and analyze publications included in the online Web of Science database. The

knowledge infrastructure that is recovered from this search is exhaustive and documents the collaborative works of researchers, institutions, countries, and outlets within the linguistic domain. It allows us to determine how this network shapes, generates, distributes, and preserves intellectual knowledge about the SLA domain. This is an important finding, as these uncovered networks provide us with a visual interpretation of how collaborative relationships create new knowledge in the form of publications as well as which authors and institutions are particularly influential. By analyzing the keyword networks of the domain, the SNA technique also helps to shed light on some of the emerging and fading research themes that are shaping the study of SLA. As no previous study within this linguistic domain has incorporated SNA techniques as part of its methodological structure, these types of contributions are important as they to help to define the field of SLA research itself.

Given the growth of the SLA field in recent times (see Figure 1), the SNA analysis tool provides linguistic researchers with an opportunity to better understand the way in which knowledge and information is disseminated within its boundaries. By searching the Web of Science (WoS) database using a range of highly relevant keywords, this study utilizes the SNA tool to create four distinct types of co-authorship networks, (1) authorship, (2) institutional, (3) source bibliographic coupling and (4) keyword networks (title and abstract). The results of which will provide a visual interpretation of how collaborative relationships create new knowledge within SLA research.

3.2 Explanation of terms used in Social Network Analysis

Given the technical nature of the terms used as part of the SNA, it is prudent that time is taken to explain the various network-level and node-level parameters that are used to define the SLA domain. Firstly, from a network-level perspective, each individual component, while categorized by its own set of colored nodes, refers to a situation in which a part of the network is completely disconnected from other nodes (Hanneman and Riddle, 2005). The largest individual component of a network is defined as the core, while a network's diameter describes the linear size of the network and is a representation of how long it takes for information to pass through the network (Wasserman and Faust, 1994). Density demonstrates the ratio of links as a total of all possible links in a network. In this instance, a density of 1 means that all of the nodes in a network are connected to one another. The clustering coefficient shows the ways in

which the nodes cluster together and helps to detail how the various actors are prepared to work together. Finally, average degree documents the average number of links that exist among the different nodes in a network (see Table 1 for a descriptive analysis of the SLA domain). Secondly, the node-level properties describe key attributes of a network's nodes. The degree centrality of a particular node measures the number of links a node has with another particular node. Eigenvector centrality analyzes the importance of a node in a network based on how it is connected with other important nodes. The notion of betweenness centrality relates to the centrality of a node within a network and helps to explain how a node collaborates and facilitates information and knowledge in a network (Liu, et al., 2005).

3.3 Data

In order to conduct a SNA of the linguistic domain, a search was performed on the WoS database to retrieve all second language acquisition related studies. The following research query was entered into the WoS search engine:

Searched for topic: (Native language OR target language OR first language acquisition OR second language acquisition OR foreign language acquisition OR third language acquisition OR multilingualism OR bilingual acquisition OR heritage language acquisition OR contrastive analysis hypothesis OR child second language acquisition OR adult second language acquisition OR interlanguage transfer OR universal grammar OR classroom language OR teach ability OR learn ability OR social interaction approaches OR interlanguage pragmatics) Time span: 1986-2015. Coverage all databases.

The results from the WOS search query lead to the retrieval of 5,310 studies, these included 3,396 (64%) research articles, 1,188 (22%) book reviews, 293 (6%) meeting abstracts, 219 (4%) editorial materials, and 139 (2%) proceeding papers. Of the published journal articles the top 10 outlets were dominated by leading SSCI indexed publications (see Table 1). The publications themselves were written in a range of languages, of which the vast majority were written in English (4,880), however other publications were written in German (194), French (81), Spanish (73) and Italian (23).

Table 1: Top 15 Journal Publications.

Journal	Number of Publications (1986-2015)
Modern Language Journal	279
Foreign Language Annals	120
Studies in Second Language Acquisition	106
Canadian Modern Language Review	101
TESOL Quarterly	86
Applied Linguistics	79
Second Language Research	72
Hispania A Journal Devoted to the Teaching of Spanish and Portuguese	70
Language Learning	65
Applied Psycholinguistics	57
Bilingualism Language and Cognition	48
Journal of Multilingual and Multicultural Development	46
International Journal of Bilingualism	41
Language	39
Language in Society	38

From our data analysis of the linguistic domain, the field of SLA has also been growing a solid rate with the number of listed publications increasing throughout the 1986-2015 period (see Figure 1).
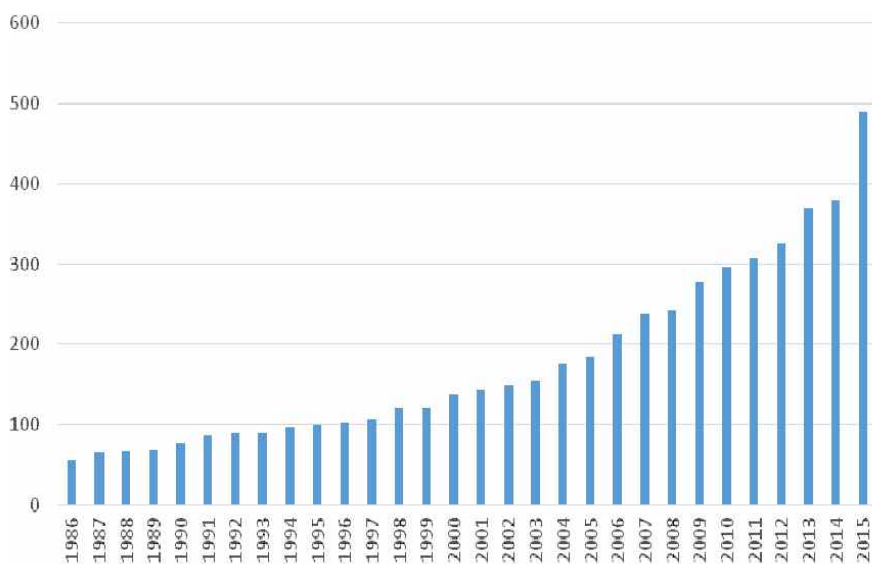

Figure 1: Publications Per Year, 1986-2015

The knowledge and semantic networks associated with these results were developed and analyzed using NodeXL[2] (Smith, et al., 2010) which visualized the institutional level network Pajek[3] (Nooy et al., 2005) which examined the structural holes and hubs that were located in the network. In addition to this, the Science of Science[4] (Sci2Team, 2009) was used to interpret the author level network, while VOSviewer[5] (Van Eck and Waltman, 2010) was used to document the author, institution, and bibliographic coupling, and keyword networks.

This research manipulates the SNA tool to create four distinct types of co-authorship networks, (1) authorship, (2) institutional, (3) source bibliographic coupling and (4) keyword networks (title and abstract). Author networks form when authors published in journals form co-authorship relationships. The institutional network is created when institutions that publish papers in journals form co-authorship ties. Source bibliographic networks are formed based on the references that sources share.   Keyword networks are created by examining the title and abstract keywords used by authors in SLA publications.

4. Results and Analysis

4.1 Author networks

Table 2 shows the network-level properties of the SLA author network. In this network some 9,220 authors were represented. Of this, the largest component had

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2   NodeXL is a free, open-sourced network analysis and visualization software package that works with Microsoft Excel 2002/2010/2013/ and 2016 platforms. It is intended for users that have little or no programming experience to allow them to collect, analyze, and visualize a variety of networks.

3   Pajek is a program for Windows that allows for the analysis and visualization of large networks. It allows the researcher to find clusters of similar components within a network and display them in visual form, making it much easier to analyze very large data and network sources.

4   The Science of Science (Sci2) tool is a modular toolset specifically designed for the study of temporal, geospatial, topical, and network analysis and visualization of scholarly datasets at the micro (individual), meso (local), and macro (global) levels.

5   VOSviewer is a software tool for constructing and visualizing bibliometric networks. These networks may for instance include journals, researchers, or individual publications, and they can be constructed based on co-citation, bibliographic coupling, or co-authorship relations. VOSviewer also offers text mining functionality that can be used to construct and visualize co-occurrence networks of important terms extracted from a body of scientific literature

398 (4.3%) authors (see Figure 2). In the author network (shown in Figure 1) node size represents betweenness centrality, while link width represents collaboration intensity. Nodes that display associated labels represent authors that have published 10 or more studies. As the results for the author network show (see Table 2) the average degree (i.e., average number of co-authored papers) was 7.437; the density was 0.02, the diameter was 13, and the average clustering coefficient was 0.88. From the analysis we can conclude that the network is fragmented with several isolated clusters of authors working in isolation. And the network does not contain one large core community of authors.

Table 2: Summary of the network level properties for the SLA domain

Networks		Nodes /Edges	Density	Average Degree	Diameter	Clustering coefficient
Author Network		1398/1480	0.02	7.437	13	0.88
Institution Network		1133/2510	0.04	4.43	13	0.47
Journal Network		93/2823	0.66	60.71	4	0.81
Keyword Network	Abstract	409/72949	0.87	356.72	2	0.90
	Title	234/5879	0.20	50.25	3	0.51

Figure 2 visualizes the author network and it shows the important role that leading authors play within the SLA domain. In this regard, node size refers to the influential role a particular author plays within the network. The width of link shows the strength of collaborative ties between the various nodes. In other words, the larger the node the more important the author is to the SLA domain and the level of collaboration that exists between the respective author and other influential linguists. In this study, Ganschow, L. Justice, L. Montrul, S. and Ellis, N. were found to be particularly influential.

Meanwhile, in Figure 3 we are able to see the impact of each author to the field of linguistics. In this regard, the larger the node the more significant the influence to the field of SLA. Key author's identified from our analysis include Ganschow, L., Plomin, R., Paradis, J., and Montrul S., Ellis, N. C., and Sebastian-Galles, N., and Slabakova, R. The studies in which they are involved in range from works on psycholinguistics, neuro-psycholinguistics, teaching linguistics in a classroom environment through to speech acquisition and general second language research.
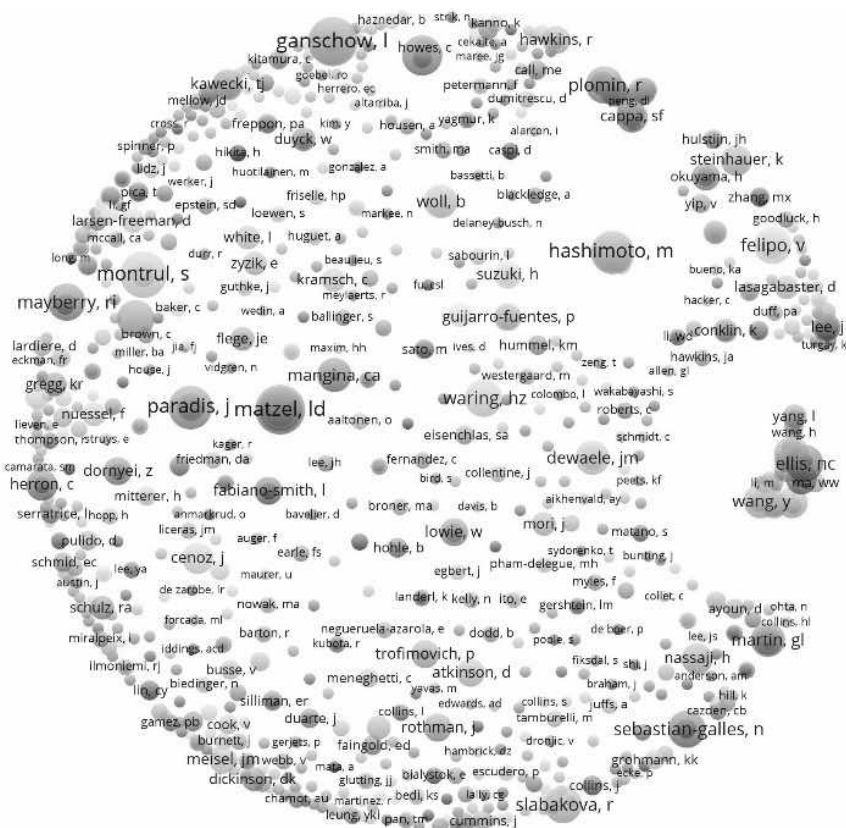
Figure 2: Authors network

Figure 3: Author network (N=9220); largest component (398)

4.2 Institution network

The institutional network properties of the SLA domain are shown in Table 2. In this network, the total number of institutions was 2,236. However, as part of our analysis we only included the largest connected component which had 1,133 (see Figure 4). As was the case with our earlier author network analysis, node size represents betweenness centrality (in other words the degree to which the institution is a central figure in SLA research), while link width refers to collaboration intensity (which refers to the number of collaborative studies that have taken place between the academic institutions). Labelled nodes reflect institutions that contain 20 or more articles or links.

Figure 4: Institutional network

The results of our institutional analysis, as shown in Table 2, demonstrate that the show that the average degree was 4.43; the density was 0.04 which suggests there is a very low level of collaboration between all of the institutions which was to be expected, the diameter was 13, and the average clustering coefficient was 0.47. These results highlight the need for greater research collaboration between academic institutions with much of the current SLA research centered around North-American Universities.
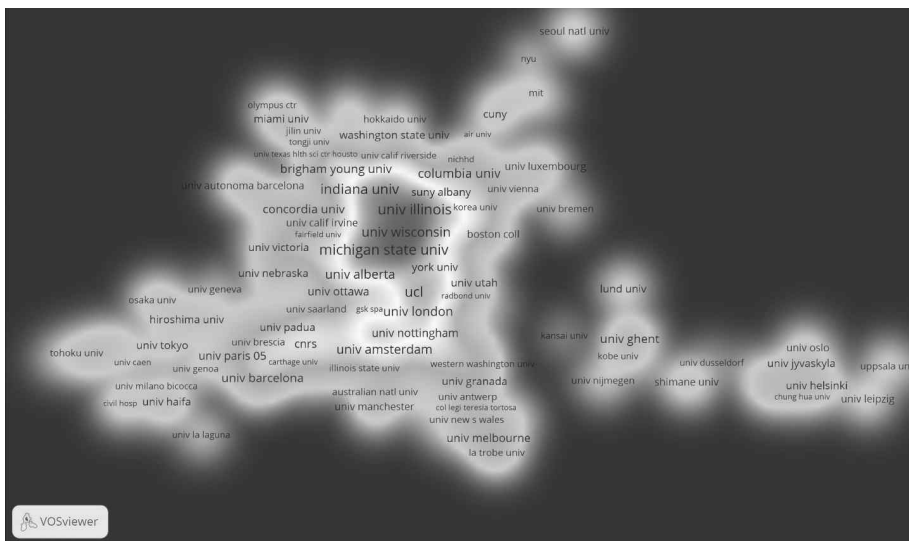

Figure 5: Institutional collaboration network heat map (N=1,133)

In order to help understand which institutions were at the center of SLA research a heat map was developed (see Figure 5). This form of visualization not only defines prominent institutions it also helps to demonstrate the fragments that exist within the network. In this regard, the University of Illinois and Michigan State University feature in this networks main cluster and are visible in the areas highlighted red. The greener areas branching out from this reflect various fragments within the network and demonstrate smaller aspects of institutional collaboration.

In addition to heat map analysis, we analyzed the top 10 academic institutions from a degree centrality perspective (see Table 3). The results show that the leading institutions within the network include Ohio State University, the University of

Illinois, the University of Barcelona and Oxford University.   In terms of degree centrality, Ohio State University is highest ranked which suggests the institution has the greatest number of links with other universities. However, the University of Illinois, by being the highest ranked for betweenness centrality suggests that it is centrally placed within the network, a finding that is line with the institutions location within the heat map visualization (see Figure 5). Finally, the eigenvector findings demonstrate the important role the University of Barcelona and the University of Oxford play within the knowledge network as both are the best placed to take advantage of connections with other highly influential institutions (nodes). Overall these leading universities are well positioned to absorb and contribute to the level of knowledge included within the SLA domain. From this finding we can deduce that scholars working at these institutions

Table 3: Top 10 institutions in term of degree centralities

Degree	Betweenness	Eigenvector
Ohio state University	University of Illinois	University of Barcelona
University of Barcelona	Radboud University of Nijmegen	University of Oxford
University of Illinois	Ohio State University	University of Kiel
University of Oxford	Penn State University	University of Porto
Radboud University of Nijmegen	University of Oxford	University of Antioquia
University of California San Diego	McGill University	Fed University of Para
UCL	University of London	University of Complutense Madrid
Harvard University	University of Cambridge	University of Zulia
Penn State University	University of Hong Kong	University of Buenos Aires
McGill University	University of Jyvaskyla	UNMSM University

4.3 Source bibliographic coupling

The bibliographic coupling aspect is determined based on the references sources share. From this study, out of the 1471 outlets included only the outlets that contain

at least 10 publications (n=93) were included in the bibliographic coupling analysis. Figure 6 provides a visual interpretation of the source bibliographic coupling network. In this instance, nodes reflect academic journals, while the links drawn among the nodes demonstrate the level of relationships that exist between references. The size of the node represents the number of documents that have been analyzed for each source. In an attempt to ensure better visibility, the numbers of links are reduced, labels are trimmed, and the overlapping node labels are not shown. Node color indicates clustering groups. Based on the bibliographic coupling the 93 journals are grouped into 6 clusters. Node color indicates clustering groups. In the purple cluster contains 15 nodes, from which the leading sourced publications (based on node size) include the Modern Language Journal, the Foreign Language Annals, the Canadian Modern Language Review, and the Journal of Applied Linguistics. The yellow cluster, containing 12 nodes, includes a number of important publications such as the Journal of Applied Psycholinguistics, the International Journal of Psycholinguistics, and the Journal of Child Language. The red cluster contains 21 nodes. The most significant publications in this grouping include the Journal of Bilingualism-Language and Cognition, Frontiers in Psychology, The Journal of Psycholinguistic Research, and the Journal of Phonetics. The green cluster contains 20 nodes. The leading journals within the cluster include Studies in Second Language Acquisition, Second Language Research, Linguistic Approaches to Bilingualism, and the Journal of Linguistics. The blue cluster has 17 nodes from which the International Journal of Bilingualism, the International Journal of Multi-Linguistics, the Journal of Multilingual and Multicultural Development, and the Journal of Sociolinguists are most prevalent. Finally, the aqua cluster which contains only 6 nodes has the Journal of Computers and Education and The Computer Assisted Language Learning Journal as its leading publications. Given Figure 6 reflects the most important publications in the SLA domain, our SNA shows the most significant publications overall (based around node size) are the Modern Language Journal, TESOL Quarterly, Studies in Second Language Acquisition and the Foreign Language Annals. The practical implications of this are important as it highlights the publication outlets that will provide the highlight degree of visibility for linguistic scholars.
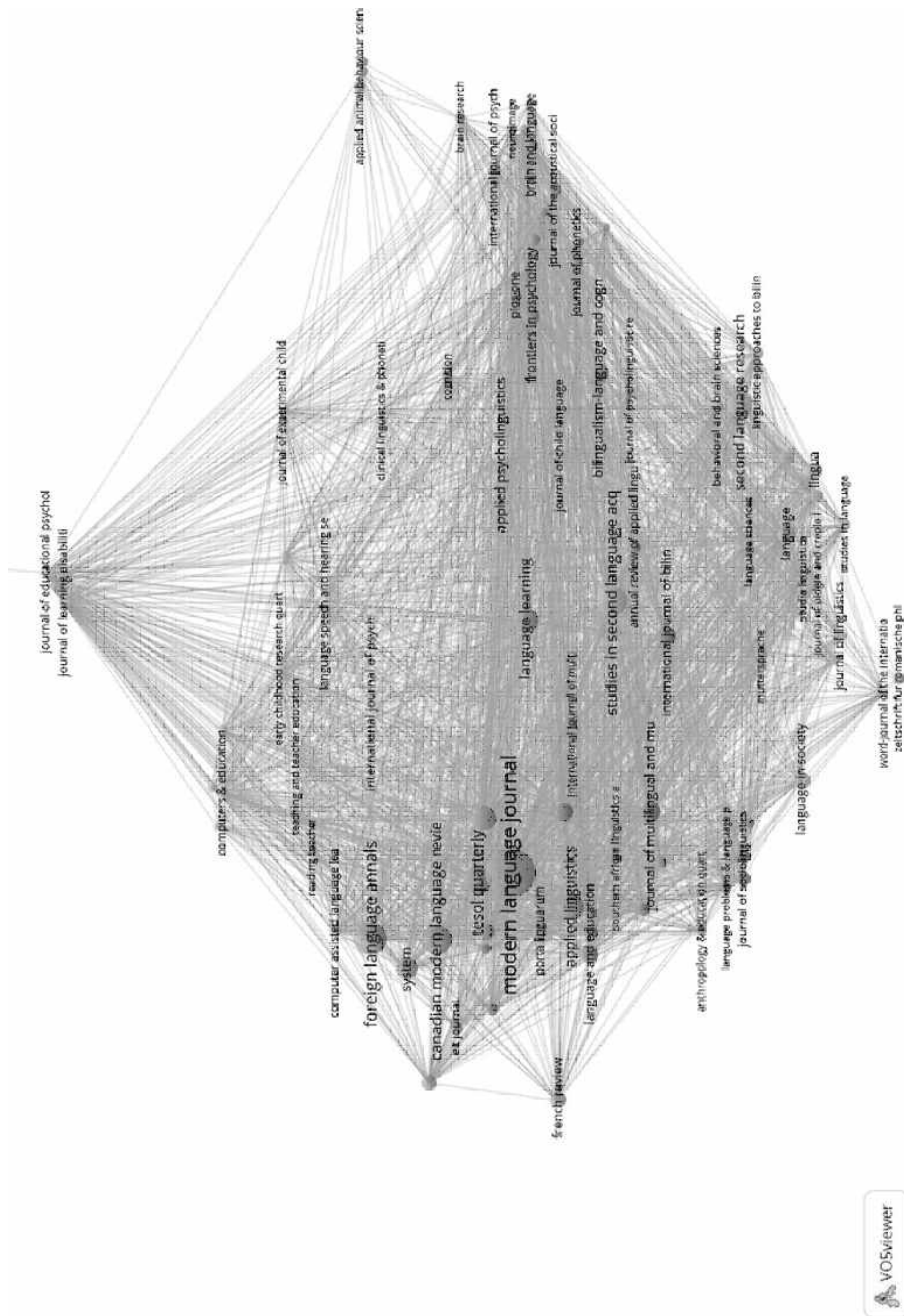
Figure 6: Bibliographic coupling network

In order to provide further clarity as to the relative importance of each publication outlet a bibliographic coupling heat map was constructed (see Figure 7). In this instance, the Journal of Modern Language, the Foreign Language Annals, the Canadian Modern Language Review and the Journal of Applied Linguistics are centrally positioned within the SLA network.
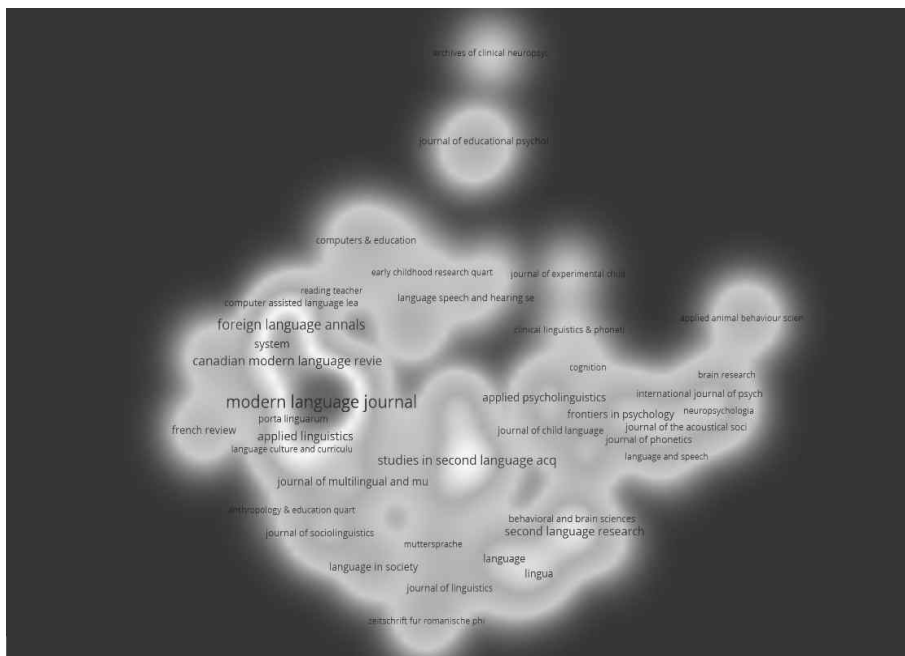

Figure 7: Bibliographic coupling heat map (N=341)

In addition to our heat map analysis we also examined the degree centralities and Fr attributes of the SLA network (see Table 4). From our analysis we can deduce that the Modern Language Journal is well placed from a degree, betweenness, and eigenvector centrality perspective. This suggests that the journal is well linked to other important publications within the SLA domain. In other words, it is not only well placed to influence the way in which information and knowledge flows throughout the network, but it is also best placed to take advantage of connections with other highly influential publications (nodes).   Other important publications include the Journal of Language Learning, the Canadian Modern Language Review, Studies in Second

Language Acquisition and the Journal of Applied Psycholinguistics. From a Co-citation perspective, our study shows that given the significance of the Modern Language Journal to the bibliographic coupling network, it is well placed to be co-cited with other leading publications such as the Journal of Language Learning, the Foreign Language Annals, the Journal of Applied Psycholinguistics, and the Journal of Applied Linguistics. In summary, these findings help to demonstrate the key publication outlets for research within the domain of SLA research.

Table 4: The top 15 sources in terms degree centralities and co-citation

Degree	Betweeness	Eigenvector Centrality	Co-citations	
Modern Language Journal	Journal of Educational Psychology	Modern Language Journal	Canadian Modern Lagunage Review	Modern Language Journal
Tesol Quarterly	Plos One	Language Learning	Foreign Language Annals	Modern Language Journal
Language Learning	Modern Language Journal	Canadian Modern Language Review	Language Learning	Modern Language Journal
Canadian Modern Language Review	Zeitschrift Fur Romanische Philologie	Tesol Quarterly	Applied Linguistics	Modern Language Journal
Applied Psycholinguistics	Lingua	Studies in Second Language Acquisition	Modern Language Journal	Tesol Quarterly
Studies in Second Language Acquisition	Tesol Quarterly	Applied Psycholinguistics	Applied Psycholinguistics	Second Language Research
Bilingualism-Language And Cognition	Studia Linguistica	International Journal of Bilingualism	Bilingualism-Language and Cognition	Second Language Research
International Journal of Bilingualism	Language Learning	Applied Linguistics	Language Learning	Second Language Research
Second Language Research	Canadian Modern Language Review	Second Language Research	Applied Linguistics	Language Learning
Applied Linguistics	Brain Research	Bilingualism-Language and Cognition	Bilingualism-Language and Cognition	Language Learning

Frontiers in Psychology	Applied Psycholinguistics	Language Teaching	Language Teaching	Modern Language Journal
Journal of Multilingual and Multicultural Development	Bilingualism-Language and Cognition	Hispania-A Journal Devoted to the Teaching of Spanish and Portuguese	Applied Psycholinguistics	Language Learning
International Journal of Bilingual Education and Bilingualism	Frontiers in Psychology	Annual Review of Applied Linguistics	Modern Language Journal	System
Foreign Language Annals	Studies in Second Language Acquisition	Foreign Language Annals	Canadian Modern Language Review	Foreign Language Annals
Annual Review of Applied Linguistics	International Journal of Bilingualism	International Journal of Bilingual Education and Bilingualism	Linguistic Approaches to Bilingualism	Second Language Research

4.4 Keywords Networks

The keyword analyses performed in this social network analysis study of the SLA domain examined both title and abstract keyword networks.

4.4.1 Title Keywords Networks

A total of 5879 terms were identified in the titles of the articles; however, only the terms that occurred at least 5 times (n = 234) were included in the analysis (see Figure 8). In Figure 8 node size represents the number of occurrences a keyword is present while the links represent co-occurrence relationship. Based on these co-occurrence relationships, words are grouped into six clusters as represented by the colors of the nodes. Cluster one (red nodes) is dominated by the keywords of second language acquisition, classroom, language learning, research, and second language classroom. In cluster two (cyan nodes) the dominant keywords include English, Spanish, study, and community. In cluster three (green nodes) the major keywords include student, child, approach, and strategy. In cluster four (purple nodes) the most significant terms are ability, effect, learning, memory ability, memory, and difference.

Figure 8: Title Keyword Network

In cluster five (blue nodes) the keywords include acquisition, second language, age, language acquisition, native language and foreign language. Finally, in cluster six (yellow nodes) the dominant keywords include education, practice, analysis, perspective, and pedagogy.
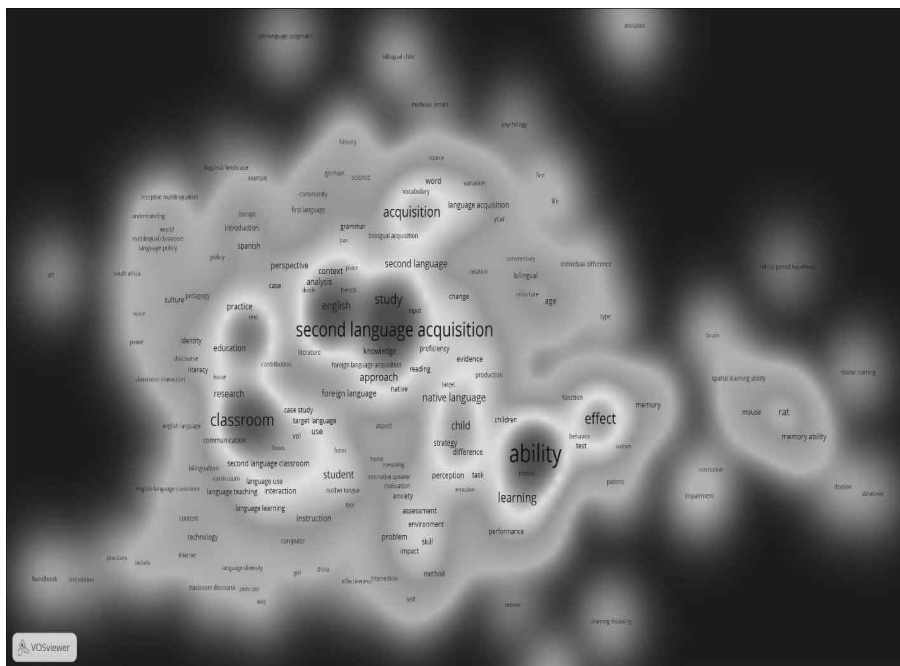

Figure 9: Title Keywords co-occurrence (N=234)

In order to provide greater perspective on the title keyword results a heat map (see Figure 9) was developed in order to provide a more detailed understanding of the important terms and the ways in which they are clustered together in groups. In this instance, the hottest terms include second language acquisition, ability, effect, classroom, and learning.

4.4.2 Abstract Keywords Network

A total of 72949 terms were identified in the titles of the articles; however, only the terms that occurred at least 5 times (n = 409) were included in the analysis (see Figure 10).

Figure 10: Abstract Keyword Network

Based on these co-occurrence relationships, words are grouped into four clusters as represented by the colors of the nodes. Cluster one (red nodes) is dominated by the keywords of data, ANOVA student, classroom, research, teacher, and language learning. In cluster two (blue nodes) the dominant keywords include study, result, effect, task, age, method, activity, memory ability and task. In cluster three (green nodes) the major keywords include language, acquisition, child, system, participant, speech, and experiment. In cluster four (yellow nodes) the most significant terms are skill, year, quality, grade, outcome, and vocabulary.
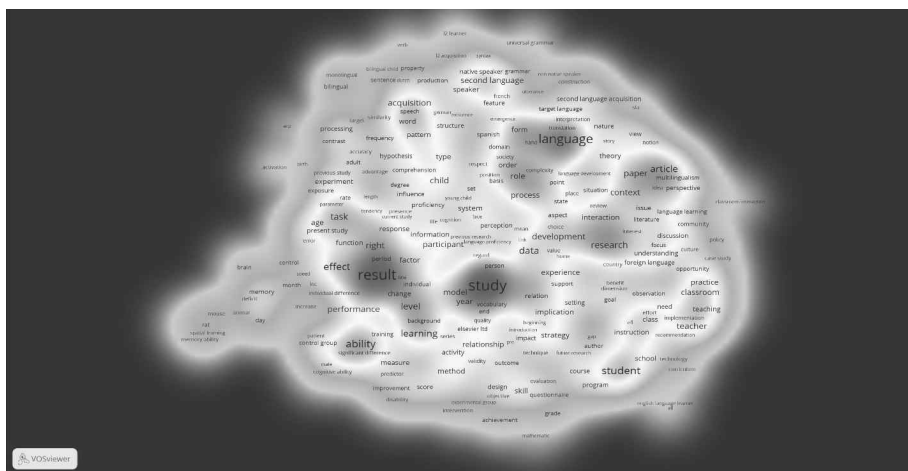

Figure 11: Abstract Keywords co-occurrence (N=409)

As was the case with the title keyword network, a heat map was constructed to visualize the important terms used in the abstract analysis (see Figure 11). In this instance, we are able to clearly determine the ways in which the keywords are clustered in their various groupings. The results from these clusters show that language, result, study, ability, learning, development, second language acquisition, practice, native language speaker, and language development are the key points of reference.

The top 20 latest bursting and disappearing topics are shown in Table 5. In the case when there is no end date noted, the terms are considered to still be active. The term weight is applied to the keywords. In this instance, weight represents the weight of a burst word between its lengths; therefore, a higher weight could be a result of the longer length of usage, the higher frequency, or both. For example, the word

'teacher' has the highest weight of 7.563174, meaning that the word 'teacher' has appeared more frequently in the author-supplied title keywords of the articles included in our study. Table 5 shows the key words included titles and abstracts by authors. Currently, the most significant key word trends represented in the field of SLA today from a title perspective include Multimodal (2013-present), global (2010-present), technology (2014-present), L2 (2015-present), EFL (2013-present) and memorization (2014-present). These highlight important areas of today's current research themes. In addition to this, our abstract keyword analysis showed that plurilingualism (2013-present), English as a Foreign Language (EFL) (2013-present), ANOVA (2015-present), model (2015-present), technology (2016-present) and questionnaire (2016-present) are key aspects of SLA research. On the other hand, Table 5 also documents areas of research that are not as significant as they once were and as a result fail to be included in either title or abstract lists; these include from a title keyword perspective, the likes of UG or universal grammar as it commonly referred to (1987-1996), 2nd language (1987-1995), syntax (1996-2006), Japanese (1998-2005), postnatal (1992-2003), and psycholinguist (2002-2008) are no longer as popular as they once were. While the abstract keywords that are no longer as prevalent as they were in the past include Wechsler (1192-2006), UG (1995-2009), Neuropsychology (2000-2008), and ERP (2008-2013).

Table 5. The top 20 latest bursting and disappearing author-supplied title and abstract keywords

Title					Abstract				
Word	Weight	Length	Start	End	Word	Weight	Length	Start	End
Teacher	7.563174	1	2016		Questionnaire	6.985712	1	2016	
L2	3.918979	2	2015		Technology	5.874874	1	2016	
Memorization	5.858566	3	2014		Modal	4.426925	2	2015	
Technology	3.507531	3	2014		ANOVA	4.102158	2	2015	
EFL	5.948601	4	2013		EFL	7.340193	4	2013	
Multimodal	3.808847	4	2013		Plurilingualism	4.273333	4	2013	
Implicit	3.455328	5	2010	2014	Multilingual	10.24938	3	2012	2014
Global	3.841409	7	2010		Franca	3.70105	3	2012	2014
Online	4.964011	4	2009	2012	Pedagogical	4.804147	3	2010	2012
Vocabularies	3.601144	5	2009	2013	ERP	3.535651	6	2008	2013
Sentence	3.681682	4	2006	2009	Mothertongue	5.402127	2	2007	2008
Psycholinguist	4.22619	7	2002	2008	Wagner	3.658148	2	2006	2007
Receptors	3.658257	6	2001	2006	Explicit	4.109924	1	2006	2006

Japanese	7.659603	8	1998	2005	Judgement	3.525016	4	2005	2008
Syntax	4.900299	11	1996	2006	L2	3.475098	1	2004	2004
Instruct	4.492086	5	1995	1999	Neuropsychology	3.672301	9	2000	2008
Postnatal	4.1609	12	1992	2003	Singular	4.724571	7	1998	2004
2nd-language	14.71372	9	1987	1995	Physiology	4.044784	10	1997	2006
Cooper	4.26656	12	1987	1998	UG	4.760686	15	1995	2009
UG	20.09709	10	1987	1996	Wechsler	6.571606	15	1992	2006

5. Discussion

As a complex and ever changing field of scholastic endeavor the SLA domain has been examined using traditional means of analysis such as tests, interviews, questionnaires, literature reviews and empirical analyses using statistical tools. While not attempting to change the way in which SLA research is fundamentally conducted, this study nonetheless utilizes the SNA technique to provide a meaningful means of examining the ways in which knowledge infrastructures are assembled within this linguistic domain.In order to do this effectively, the networked knowledge infrastructure was investigated at 4 levels: author, institution, and source bibliographic coupling, and keyword levels.

The author network analysis showed that SLA network is relatively fragmented containing several isolated clusters of authors. The study also found that the diameter of the co-authorship network is relatively small and clustering co-efficient is high. This finding implies that the SLA network exhibits what is known as the small-world phenomenon (Watts and Strogatz, 1998) which suggests that authors have a high tendency to form groups. This is an important finding as it shows the broad and highly segmented nature of a domain that includes a myriad of subsets and very specific areas of research.

From an institutional perspective, our analysis showed the important role that the University of Illinois, Ohio State University and the University of Oxford play within the field of linguistics and in particular SLA. These academic institutions have lead the way in leading publication output with leading scholars (Coleman, Oxford University; Tanner, University of Illinois; and Culicover, Ohio State University) publishing a wide range of influential linguistic and second language studies.

Our bibliographic coupling results highlighted the important role that the Modern Language Journal (Impact Factor (IF): 1.188), the Canadian Modern Language Review (IF: 0.361), the Journal of Language Learning (IF: 0.627), the Foreign

Language Annals (IF: 0.908), the Journal of Applied Psycholinguistics (IF: 1.580), and the Journal of Applied Linguistics (IF: 1.749) play in the field of SLA. Of these Journals all are listed in the Social Science Citation Index (SSCI), the leading index for scholarly publication. The impact factors (IF) listed besides each of these publications provides a good measure of their importance with half of the publication outlets having an IF that is greater than 1.

Finally, our keyword analyses helped to shed light of the areas of research that have been popular in the SLA domain. Our title keyword findings showed that the areas of important focus are second language acquisition, language learning, second language classroom, English, Spanish, and child based learning. Given that the languages of English and Spanish are the among the most common second languages learnt these results are in line with conventional wisdom. In terms of abstract keywords, the results displayed a more empirical focus as data, ANOVA, result, participant, and experiment were popular. However, the keywords of acquisition, second language, and native speaker grammar were common. While our examination of fading and emerging trends provided us with a more detailed means from which the SLA domain may be defined. In this regard, Multimodal (2013-present), global (2010-present), technology (2014-present), L2 (2015-present), EFL (2013-present) and memorization (2014-present) were found to be important emerging keywords, while universal grammar (1987-1996), 2nd language (1987-1995), syntax (1996-2006), Japanese (1998-2005), and psycholinguist (2002-2008) are no longer as popular as they once were. The fading trends highlight the important role that universal grammar and syntax has played in laying the foundation from which further studies may abound. Both are still prominent terms in their own right but as the findings suggest that may no longer be a primary focus. In addition, our abstract keyword analysis showed highlighted important areas of study plurilingualism (2013-present), EFL (2013-present), technology (2016-present) and terms associated with the empirical components of research ANOVA (2015-present), model (2015-present), and questionnaire (2016-present). In conjunction with this were the fading trends which again saw universal grammar listed.

The results of our study highlight the wide array of areas that are embedded within the linguistic domain of SLA. Terms such as technology demonstrate the evolving nature of SLA and the fact that traditional means of acquiring language are being superseded by innovation and access to higher levels of audio visual and telecommunications technology in either a classroom or home setting. While the

notions of EFL, and plurilingualism highlight growing trends in not just bilingualism but the acquisition of third or fourth language skills and abilities.

6. Conclusion

By employing the social network analysis technique, we analysed the linguistic domain of second language acquisition. In doing so we have been able to expose the hidden structures that are associated with SLA and, thus, provide a comprehensive view of the knowledge networks embedded within the domain. By utilizing a range of tools including NodeXL, Pajek, Science of Science, and the VOSviewer we were able to investigate and decompose the semantic and knowledge attributes of the author, institution, and bibliographic coupling, and keyword networks of the SLA domain. As part of this examination, we measured both the network level (components, diameter, density, clustering co-efficient and average degree) and node level (degree, betweenness, and eigenvector centralities) of 3 of the networks included in the study. The results from this analysis has seen this study make a number of key contributions to the field. This study found evidence the SLA network exhibits what is known as the small-world phenomenon (Watts and Strogatz, 1998) which suggests that authors have high tendency to form groups. In addition, this study was also able to document authors and institutions that are influential in the domain and help to explain the ways in which information and knowledge in shared amongst the network. Despite these implications the study has some limitations that need to be mentioned. For the purposes of this study, we only relied on a single database (i.e., Web of Science), therefore we may have excluded some important studies indexed in other databases (e.g., SCOPUS). Thus, caution should be exercised while generalizing the results. Nonetheless, our social network study provides a ground-breaking examination of the SLA domain and a unique perspective on how information and knowledge in shaped within its borders.

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