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主　論　文　の　要　旨

論文題目	Longitudinal Network Structure Changes of Linguistic Features in L2 Writing Development: An Exploratory Study Employing Complex Dynamic Systems Theory (第二言語ライティング能力の発達における言語指標ネットワーク構造の縦断的変容―複雑動的システム理論を援用した探索的研究―)
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論　文　内　容　の　要　旨

With the recognition of the limitations of construct reductionism, a Complex Dynamic Systems Theory (CDST)-based research on L2 development has garnered considerable interest in recent years, in order to overcome the shortcomings of reductionist practice. CDST is a metatheory focusing on interactions within and between systems, examining processes in detail; it is a different approach for researching processes that have already been investigated in the past. This study is an exploratory research that aimed to analyze longitudinal L2 writing development from a CDST perspective, employing network analysis to visualize the interactions between and within systems and subsystems.

The author drew written data from a learner corpus, which includes longitudinal written data over an eight-week period by Japanese learners of English. Networks were delineated on the basis of the correlation coefficients between syntactic, lexical, and error features over the same period. Three centrality measures were calculated to interpret the longitudinal structure changes of the network. Results showed that the network structures changed over time; three subsystems were detected, and their structure was also dynamic over time. On the basis of the results, the author discusses L2 writing development in terms of longitudinal systems change and its interactions, as well as theoretical and methodological significances for L2 development research from a CDST perspective. This doctoral dissertation comprises six chapters; a brief overview is presented below.

Chapter 1 describes the research motivation and background of this study, highlighting three major problems related to the methodology of measuring L2 productive ability that have been practiced in a reductionist manner; the adverse effects of this are identified, and CDST is introduced as a solution to overcome the limitations of construct reductionism. The author describes the advantages of capturing such L2 ability from the perspective of CDST, rather than in accordance with the conventional method. In addition, the author points out the problems of extant CDST

research methodology and offers the advantages of capturing L2 development in terms of a system with network analysis. Chapter 1 ends with a summary of the issues to be resolved and describes the scope of this doctoral dissertation study.

Chapter 2 first presents a succinct history of measuring L2 performance from the 1950s to the 2010s, and contextualizes the introduction of the framework of Complexity, Accuracy, and Fluency (CAF); it then examines the interdependency of CAF and their interactions. This is followed by a detailed review of the construct measurement models, namely the reflective model and formative model, in measuring a latent variable that has rarely been taken into consideration in the field of Second Language Acquisition (SLA) and the importance of these models is highlighted. In addition, the author also illustrates the problems of the operationalization of a latent variable based on reductionist practice in the literature. With this background in mind, the study introduces a new theoretical framework, namely CDST, to overcome the shortcomings of construct reductionism and review previous studies that have researched L2 development through a CDST lens. With the review, the author identifies both theoretical and methodological limitations in previous studies and offers issues to be solved in this thesis. The research questions are thus as follows:

RQ1: Does the network structure of the system in L2 writing change over time with the development of L2 writing?

RQ2: Does a measure that plays a central role in identifying the center of interactions in the network structure of the system in L2 writing change over time with the development of L2 writing?

RQ3: Can the network structure of the system in L2 writing be observed in each subsystem of complexity, accuracy, and fluency at specific points? If so, can the three subsystems be maintained over time with the development of L2 writing?

Chapter 3 describes the methodology of this thesis. The author first enumerates the above research questions and explains how they will be approached. Specifically, the author describes the content of the longitudinal data used in the study and the data collection method. The data used in this study is *the Nagoya Interlanguage Corpus of English for SLA Testbed* (NICEST), which consists of 1,836 learner essays written by Japanese EFL learners each week over a period of eight weeks as course assignments. All the essays in NICEST are given an essay score on a scale of one to six. Further, the author lists a large variety of linguistic measures to construct an L2 writing system and presents tools that provide an automatic analysis of such linguistic measures, namely *L2 Syntactic Complexity Analyzer* (SCA), *Lexical Complexity Analyzer* (LCA), and *ERRor ANnotation Toolkit* (ERRANT). SCA is an automatic calculation tools of nine linguistic features and can generate fourteen syntactic complexity measures on the basis of such nine features. LCA

can output seven types of token and type frequency measures such as word tokens, word types, verb token, verb types, and so on, and can generate 25 lexical complexity measures that have been used in previous studies. ERRANT is a tool that automatically extracts and classifies grammatical errors in parallel original and corrected sentences.

Then, since the network analysis is the new game in town, the author explains its installation process, mechanism, and method of interpretation in detail—particularly, an algorithm of the delineation of the network, the definition of centrality measures, and community detection to identify subsystems on the network. The algorithm to delineate networks in this study is the *Fruchterman-Reingold* algorithm, which is designed to calculate the nodes that repulse each other and those attracting associated nodes; the network will then depict when the figuration change between nodes was at a minimum. Not only is the structure of a network interpreted by the appearance of the network itself, but it is also assessed by the centrality indices. This thesis employs the following three centrality measures: degree centrality, closeness centrality, and betweenness centrality. Further, the network shows a property by which the density between nodes with close relations becomes high. A high-density part in the network forms a subgroup, and a group of nodes that can be distinguished from other subgroups formed in the network is extracted by evaluating the subgroup's cohesiveness index. The method of detecting subgroups based on the cohesiveness in a network is called community detection. It enables us to understand the behavior of network structure comprehensively from a higher perspective. This study adopts a *spin glass* algorithm in detecting a community in a network. A summary of analytical procedure concludes Chapter 3.

Chapter 4 first shows that L2 writing ability in the data is developed over eight weeks based on the change of mean essay scores between the first week and the eighth week in each data, namely combining Group A and Group B, Group A alone, and Group B alone. As there is a significant difference in the mean essay scores of these three datasets between the two time periods, the learner's L2 writing ability is considered as being developed over eight weeks. The author will then summarize the results, which applies network analysis to the total data of Group A and Group B, the data of Group A alone, and that of Group B alone, respectively. In total, twenty-four networks will be shown as the results of the analysis in order to approach the research questions.

Offering a brief summary of findings here, the network structure of the overall trend did not experience dramatic changes over eight weeks compared to those of Group A and Group B. Visually, it had a similar structure and maintained three communities over eight weeks. Where the overall trend was different between that of Group A and Group B, the part with strong interaction was maintained for eight weeks and the part of the weak interaction was also maintained for eight weeks. The nodes belonging to the communities did not changed much over eight weeks. In light of the centrality measures, over the eight-week period, the trend of the degree centrality shows that the basic linguistic units such as the number of sentences (S), the number of T-units (T), the number of clauses (C), and so on, tend to be higher, although only in the second week did the number of

complex nominals (CN) have a higher degree centrality. The trend of closeness centrality is that the number of words (W) and C have a higher closeness centrality, and nodes with a higher closeness centrality are absolute values. The trend of the nodes with a high betweenness centrality is different from that of other centralities. Not only the absolute value measures, but also the mean value measures and error measures had a high betweenness centrality over eight weeks.

In Group A, longitudinal changes in network structure over eight weeks experienced a drastic change compared to the results of the overall trend. The L2 writing system of Group A is not considered stable, but dynamic. Although the structure changed dramatically over eight weeks, the number of communities on the network remained at three. Visually, the distance between nodes gradually decreased over eight weeks, and the L2 writing system was observed to move from a dynamic state to a stable state. In light of the centrality measures over eight weeks, the trend of the degree centrality shows that, at the initial developmental stage of L2 writing, basic linguistic units such as S, T, W, and so on is high; however, at the later stage, the degree centrality of word types is also high in addition to such units. The trend of closeness centrality shows that S, T, C, W, and word types are high throughout eight weeks. Following the trend of the nodes with a high betweenness centrality, a tendency to increase the centrality of missing errors was observed, in addition to the basic linguistic units.

In Group B, the network structure over the eight weeks experienced more dramatic change than that of Group A. The biggest difference between the networks of Group A and Group B is that Group B's network has changed the number of communities over time. The number of communities decreased from three to two in the first and seventh week. From these results, the L2 writing system of Group B is also considered not to be stable but dynamic, similar to that of Group A. Visually, the network structure gradually converged with each week. Interestingly, the network structure of both Group A and Group B is similar in the eighth week despite there being a considerable gap in the structure in the early stage.

Chapter 5 discusses the general findings of the study, particularly the change and behavior of the L2 writing system and its interaction over time. Considering the synthesized data, the network structure did not reveal any dramatic changes throughout the eight weeks. One of the reasons for this could be that since the result of the overall trend included two types of essays, the effect of the prompts could be balanced out, with no dynamic structure changes over time surfacing on the network structure. Previous studies have suggested that proficiency affects system structure, but this study did not reveal such an effect. It is a major feature of the combined data that the part with strong interaction as well as the one with weak interaction was maintained for eight weeks. A system is not a simple summary of nodes, but the result of a dynamic interaction among them, and hence, there is even possibility that the L2 writing system itself is not formed on the basis of the overall results in the first place. Also, the number of communities was maintained over eight weeks, but the structure of the communities deviated from the CAF structure put forth in previous studies. On the

contrary, the network structure of both Group A and Group B underwent dramatic change, and it is intriguing that their structures differ from each other. Although this difference in network structures between the two groups could be attributable to the effect of prompts, interestingly, this is not the case. By comparing the network at each prompt, it can be observed that the network structure of the two groups completely differ even at the same prompt. If the prompt affects network structures, the structures should have been identical at the same prompt, but they are not. It is a distinctive feature that over eight weeks, the fact that completely different network structures for Group A and Group B become gradually similar through dynamic and stable states is highly interesting. It suggests that when the proficiency level is the same, the structure of the L2 writing system will be similar even though the prompt is different, and that there might be a fixed network structure depending on the development level.

Chapter 6 is the final chapter of the doctoral dissertation, which gives a summary of the study and describes both the theoretical and methodological significance of the findings. Before drawing conclusion, the author enumerates five limitations that should be kept in mind when interpreting the results and offers recommendations for future research. Finally, the author presents concluding remarks on the significance of the study, which encourages researchers in the field to tackle the issue of L2 development research by putting a CDST perspective into practice through new methodology, namely network analysis.