Theory and Practice of Second Language Acquisition
vol. 10 (1), 2024, pp. 1/39
https://doi.org/10.31261/TAPSLA.14669



**Soheil Behdarvandirad**
Texas State University, USA
https://orcid.org/0000-0003-4642-7993

# A Systematic Review of Second Language Acquisition from the Perspective of Complex Dynamic System Theory

Abstract

From the Complex Dynamic Systems Theory (CDST) point of view, second language development has unpredictable and non-linear patterns that vary from learner to learner. Keeping track of such dynamic development requires longitudinal studies with sufficient data points. The present systematic literature review attempts to present an overview on the previously conducted longitudinal studies that have investigated the development of second language subsystems from the CDST perspective. Starting from 1884 publications, the systematic searching strategy led to 45 articles which were examined in order to highlight the state of the art. The observations of the reviewed studies are conclusively supportive of the CDST principles in second language development. The synthesis of the findings of the papers will be presented and, finally, a multitude of suggestions for further research will be provided which can help future studies clarify the existing gaps that exist in the literature.

*Keywords*: second language development, second language acquisition, CDST, systematic review

## Introduction

During the past three decades a growing number of studies have started to focus on individual patterns of second language development instead of general developmental trends that can be observed among large groups (Larsen-Freeman, 1997; Larsen-Freeman, 2017; Han, 2020; Hiver et al., 2022; Rokoszewska, 2022). The introduction of Complex Dynamic Systems Theory (CDST) into the realm of applied linguistics has attracted attention to the un-

predictability and uniqueness of second language development among learners (Larsen-Freeman & Cameron, 2008; Verspoor et al., 2011). According to this theory, language consists of numerous interconnected systems where the whole system can be drastically impacted by small changes in one subsystem or in the initial state of the system (de Bot et al., 2007; van Geert & Dijk, 2002).

Unlike group studies where the focus is on general developmental patterns of larger numbers of language learners (Verpoor et al., 2021), examining second language development from the CDST perspective calls for longitudinal studies where usually fewer participants are examined (Lowie & Verspoor, 2019). Such studies have examined the development of different subsystems (e.g., syntactic and lexical complexity, accuracy, and fluency) with respect to different language skills (especially writing and speaking). This systematic literature review aims to present a general summary of the literature of CDST studies focused on second language development. After applying the inclusion criteria to the 1884 initially identified papers, 45 of them were selected for the final review. In addition to their findings, different methodological aspects of these studies are examined and compared, such as their duration, data points, number of participants, participant type, the investigated subsystems and skills, data collection methods, measurement, and, finally, as an important aim of this systematic review, the gaps and areas which require further investigation are mentioned and suggestions for future research are provided.

## Literature Review

The steps that we take during the journey of learning a new language have been of great interest for many researchers. Finding a specific path that all learners go through to acquire a second (or foreign) language can dissect this seemingly complicated developmental process. Many previous studies have tried to find general patterns in the development of various second language subskills in rather large sample sizes (Lowie et al., 2011; Verspoor et al., 2012) but such studies have inevitably overlooked the uniqueness of every individual's improvement path during the acquisition of a new language (Verspoor et al., 2021). The objective of capturing a generalizable pattern is too simplistic in reality (Larsen-Freeman, 2006, 1997). From the perspective of Information Processing model (IP model), the development of a second language follows a linear and predictable trend (de Bot et al., 2007; Shanker & King, 2002). In contrast, other theories such as Cognitive Linguistics, Functional Linguistics, Emergentism, and Competition Model take into consideration the numerous independent variables (psychological, social, environmental, etc.) that can play

significant roles at different levels of the development of a second language. Being non-linear and unpredictable, second language development has been characterized as dynamic and complex (Verspoor et al., 2017).

According to Dörnyei (2014), a system with at least two interlinked elements that can independently experience changes over time is considered dynamic or complex. Conducting empirical research in the field of dynamic systems, especially in social sciences, is indeed more difficult because of the almost innumerable interconnected elements that function independently and with each other at the same time, making the system unpredictable. The interconnectedness of all variables in a dynamic system leads to the fact that changes in one variable in the system influence the other coexisting variables, a characteristic called as "Complete Interconnectedness" (de Bot et al., 2007). Moreover, since the early states of dynamic systems are considerably influential on their development in the long run, the existence of the butterfly effect is another observable phenomenon in complex systems, causing small initial differences to have drastic long-term impacts.

From the perspective of Complex Dynamic Theory (CDST), second language development varies from person to person due to the multitude of impactful individual factors that vary among learners (de Bot et al., 2007; Larsen-Freeman & Cameron, 2008). Since this theory was introduced into the area of language acquisition about three decades ago (Larsen-Freeman, 1994), many researchers in different fields of applied linguistics have examined different aspects of CSDT in their studies (Hiver et al., 2022). This theory brings to our attention the non-linearity of second language development in addition to the variability that exists between and within learners' second language developmental patterns (van Dijk et al., 2011; Larsen-Freeman, 1997, 2006; Verspoor et al., 2008). According to CDST, language development is an emergent, context-dependent and dynamic process filled with complex connections (de Bot, 2008; Hiver et al., 2022). The developmental variability in the examined language subsystems and also the multitude of unpredictable interactions among them have been repeatedly observed in the literature (e.g., Spoelman & Verspoor, 2010; Verspoor et al., 2008; Verspoor et al., 2021; Verspoor and van Dijk, 2011). Even after averaging out a number of specific learner trajectories, Verspoor et al. (2011) as well as Larsen-Freeman (2006) have reported that the remaining developmental patterns of the examined groups were different from that of every group member. The development of different second language subsystems can take place in different orders and at different stages. In addition, the interactions between such subsystems are intertwined, adding to the complexity and unpredictability of the dynamic development. It should also be noted that while the dynamicity of second language development makes it unpredictable, it does not mean that this development is totally random (Larsen-Freeman & Cameron, 2008).

According to CDST, accurate observation of second language development requires longitudinal studies focused on the language development of individuals with enough data points (Lowie & Verspoor 2019; Verpoor et al., 2021). While the value of the contributions and findings of group studies even with few data points is undeniable, such studies are unable to keep track of the unique and flexible developmental trends of each learner. Some of the numerous cognitive and environmental factors that impact the dynamic development of a second language include motivation, anxiety, memory capacity, age, aptitude, intelligence, available learning time, available knowledge, level of education, maturity, and the amount of exposure to the new language (de Bot et al., 2007; Kliesch & Pfenninger, 2021; Zhang et al., 2022). For example, the study conducted by Piniel and Csizér (2015) indicated that learners with higher degrees of motivation and lower degrees of anxiety had more variable developmental patterns in comparison with others. Working memory capacity has been reported to correlate with the success of second language acquisition (Linck et al., 2014; Serafini, 2017). Additionally, previous studies that examined how age can influence the cognitive performance of second language learners have reported inconclusive findings. In two studies conducted by Bak et al. (2016) and Wong et al. (2019), the observations were supportive of better cognitive performance of older second language learners. However, such cognitive benefits were not reported by Berggren et al. (2020) and Ramos et al. (2016).

A multitude of previous studies have attempted to examine different areas of second language development from the CDST viewpoint. Such investigated areas include complexity, accuracy, and fluency (CAF) in speaking (Larsen-Freeman, 2006; Lowie et al., 2017; Sauer & Ellis, 2019), and writing (Larsen-Freeman, 2006; Spoelman & Verspoor, 2010; Verspoor et al., 2021; Zhang et al., 2022), in addition to vocabulary (Caspi & Lowie, 2013; Zheng, 2016), and pronunciation (Munro & Derwing, 2008). A number of previous studies have also examined how the dynamic development of a second language is influenced by issues such as self-concept (Mercer, 2011), motivation (Han & Hiver, 2018; Lowie & Verspoor, 2019; Nitta & Baba, 2015; Nitta & Baba, 2018; Zhang et al., 2022), individual differences (Lowie & Verspoor, 2019; Nitta & Baba, 2018; Pfenninger, 2022), and also corrective feedback (Fogal & Koyama, 2022). While these factors are indeed impactful on language developmental patterns, it does not mean that grouping learners by these variables can necessarily result in exactly similar learning patterns. For example, even after grouping the participants by their aptitude and motivation, no similar developmental patterns were observed by Lowie and Verspoor (2019).

Hiver and Al-Hoorie (2016) argued that the main goals of CDST research in the area of applied linguistics include (a) representations of definite complex systems at different scales; (b) identification of the outcomes of emergent systems and their dynamic patterns of change; (c) tracing and possibly modeling

the complex mechanisms of the emerging patterns; and (d) understanding how the behavior of the systems can be influenced by the relevant parameters. As a classic example among the studies that have attempted to examine and keep track of the dynamic development of second language, Larsen-Freeman (2006) examined the developmental patterns in speaking and writing of five Chinese second language learners of English at high-intermediate level of proficiency over the period of six months. The tasks that the participants were asked to complete were freely writing about past events in addition to retelling these stories orally three days after writing them. The participants completed four writing and four speaking tasks during the six-month time period. The developing linguistic subsystems under scrutiny were grammatical complexity (measured with average number of clauses per t-unit), vocabulary complexity (measured with word types per square root of two times the words), accuracy (measured with the proportion of error-free t-units to t-units), and fluency (measured with average number of words per t-unit). The results were indicative of the non-linearity of second language development, waxing and waning developmental patterns, and also inter- and intra-individual variations on the linguistic measures, all of which were supportive of CDST view of second language development. Although only four data points seem to be a small number considering the fact that tracking second language development calls for numerous data points over long periods of time (in comparison with group studies), the aforementioned study was one of the pioneering ones that examined second language learning through the CDST angle. Since then, different fields of applied linguistics have benefitted from the contributions of CDST (Hiver et al., 2022). Such areas include language acquisition (Lowie et al., 2010; Verspoor et al., 2008), educational linguistics (Hult, 2010), the evolution of language (Mufwene et al., 2017), planning and policies in language (Bastardas-Boada, 2013; Larsen-Freeman, 2018), language ecology (Kramsch & Whiteside, 2008), and sociolinguistics (Blommaert, 2014) among other realms.

While previous studies in the literature have shed light on different aspects of dynamic development of second languages, there seems to be the lack and need of systematic reviews that can offer bigger pictures of the current state of the art in this field. The aspects of the previous studies that can be investigated through systematic reviews are the general focus of previous studies, their designs, the regularities within and contrasts between their findings, and the gaps which have not received sufficient attention yet. Hence this systematic literature review attempts to address the abovementioned issues in the literature of second/foreign language development from the CDST point of view. To be more specific, the present study aimed to address the following questions:

RQ1. What are the design and methodological characteristics adopted by the CDST studies in the field (including their conduction place, duration, number of data points, number and characteristics of participants, contexts, language

skills, data collection methods, the examined subsystems, and the utilized measurements)?

RQ2. What are the important patterns in terms of findings?

# Method

## Design of Search Strategy

The online search for finding the relevant articles was done using Scopus. With the aim of finding thoroughly inclusive keywords for the search queries, after an initial scanning of the most cited papers in the relevant realm, the following string was chosen and searched for the titles, abstracts, and keywords of the articles in Scopus:

> (((“L2” OR “second language” OR “foreign language”) w/2 (development OR acquisition OR learn* OR complexity)) AND (longitudinal OR “case stud*”)) OR ((“L2” OR “second language” OR “foreign language”) AND (“complex dynamic system* theory” OR “dynamic development” OR “complex dynamic system*”))

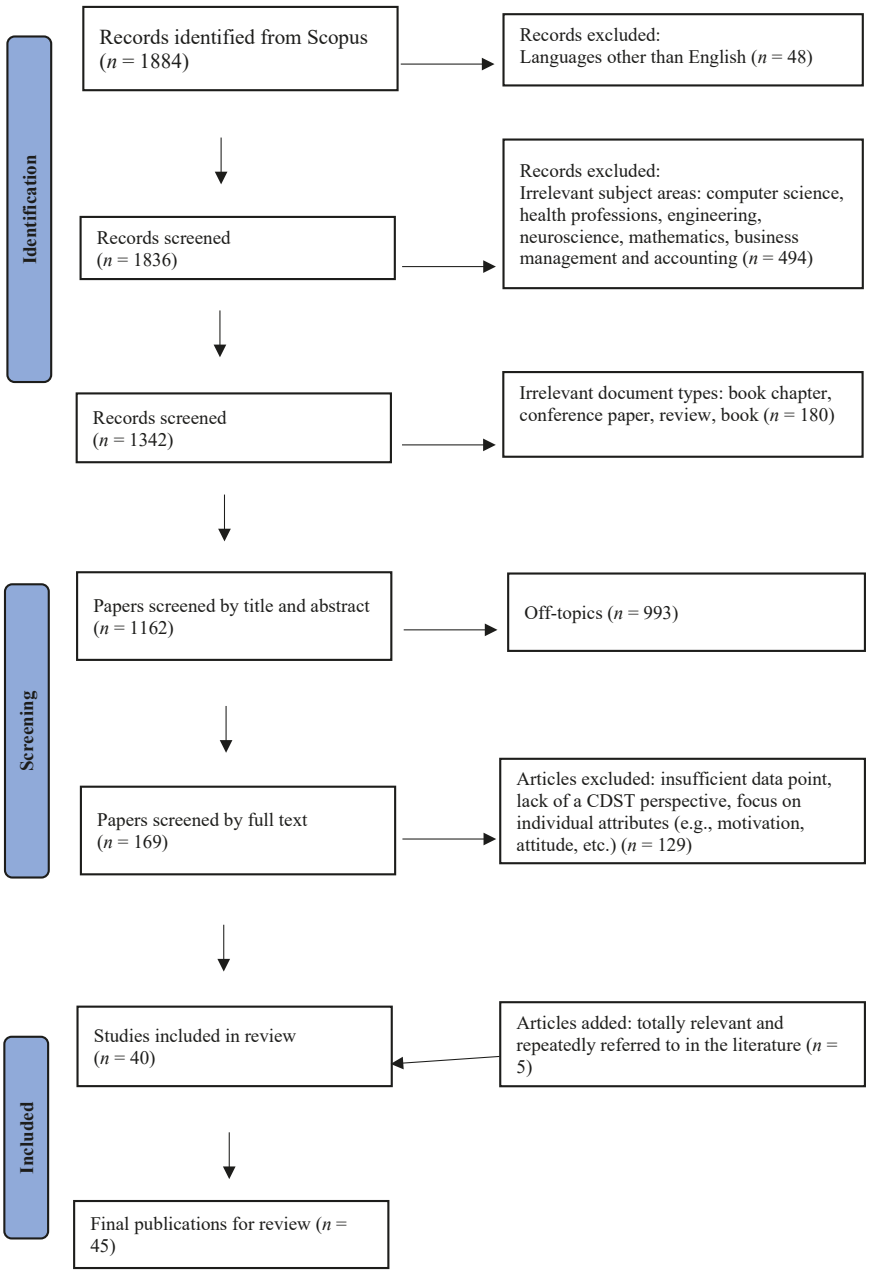
Figure 1 illustrates a PRISMA flowchart of the search process. After excluding languages other than English and also irrelevant document types and subject areas (such as “Computer Science,” “Health Professions,” Engineering,” “Neuroscience,” “Mathematics,” and “Business, Management and Accounting”), 1162 was the number of articles left. As the next step, title and abstract filtering was conducted after which 169 articles remained. Forty articles passed the full text filtering of these papers. Moreover, five additional articles were identified as studies that were referred to in the literature, were totally relevant, and completely met the inclusion criteria but had not been detected in the Scopus database search. The searching strategy led to 45 final articles that are included in the present systematic review.

More detailed criteria for the selection of the articles during the manual filtering phase were the followings:

- Publications were included only if they involved empirical research.
- Publications were included only if they were longitudinal with enough data points (at least four) since these two criteria are the fundamental elements present in studies investigating second language development from CDST

**Figure 1**

*PRISMA Flowchart of the Search Process and Identification of Studies via Databases and Registers*



perspective. Studies with these two aforementioned traits were included even if "CDST" was not mentioned in them.
- Since the purpose of this systematic review was to examine previous studies that have investigated the development of second language skills and their subsystems from CDST perspective, publications were included only if they kept track of the language development, and the ones focused on other variables such as attitude, motivation, awareness, willingness and perceptions were excluded.
- Publications were excluded if they were only concerned with the effectiveness of teaching methods and strategies and developmental patterns were not investigated.
- Publications were excluded if they were focused on newborn bilingual children who were learning two languages simultaneously. The reason for this exclusion was the fact that since newborns have not acquired their first language completely, the two languages that bilingual newborns learn at the same time cannot be distinctively identified with respect to which one can be considered as the first language and which one can be the second.

## Results

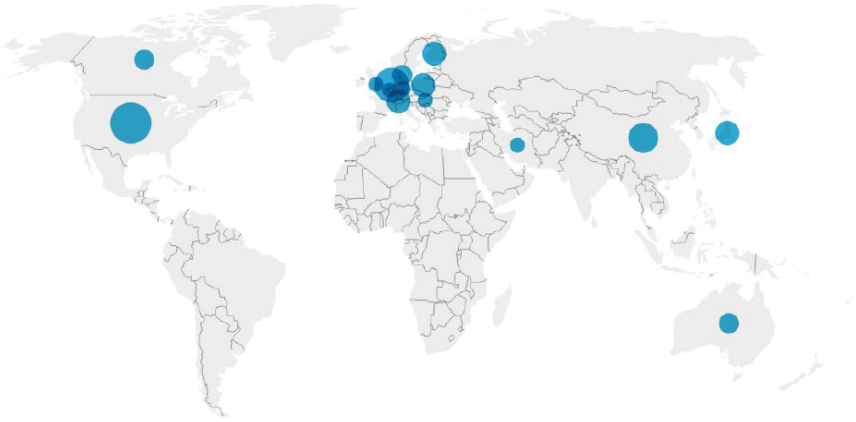
Table 1 presents an overview of the 45 reviewed studies providing information on their authors, years and places of publication, timespans, data points, the examined skills and subsystems, data collection methods, and measurement in addition to the number of participants and their backgrounds, first languages, second languages, and second language levels of proficiency. Additionally, different aspects and methodological characteristics of the articles are examined in this sections.

### Second Language Development and CDST around the World

The 45 studies examined in this review have been conducted in 16 countries. The most research was conducted in the US with ten studies, comprising almost one fourth of all of the studies. Mostly due to the works of Verspoor and Lowie, the Netherlands is the next country where the number of contributions to the literature has been significantly more than that of other countries (seven studies). Except China with five studies, the number of articles in any other country does not exceed three. Figure 2 illustrates the distribution of the conducted studies around the world.

**Figure 2**

*The Distribution of Previous Studies around the World*



## Duration and Data Points

Lengthier duration of the developmental tracking and the abundance of data points are two required fundamental characteristics of CDST in the field of second language development (Lowie & Verspoor, 2019; Verpoor et al., 2021). As can be seen from Figure 3, the duration of the longitudinal CDST studies varies from two, in Casillas (2020), to 72 months, which was the timespan of the study conducted by Pfenninger (2022). The average duration of all of the reviewed articles is almost 18 months. It is worth-mentioning that the duration of twelve studies was an academic year (nine months). Out of all of the 45 studies, 18 of them lasted at least for one year which is indicative of the importance of longer studies for the investigation of second language development from the CDST perspective.

The number of data collection points in the studies ranged from four (Larsen-Freeman, 2006) to 100 (Chan et al., 2015; Lowie et al., 2017). The approximate mean of data points among the reviewed studies was twenty-three. As can be seen in Figure 4, the number of data points that the studies had were rather evenly distributed and they were not densely clustered around a specific number. As the most repeated number of data points, participants were tested 30 times in five of the conducted studies (Baba & Nitta, 2014; Baba & Nitta, 2021; Chang & Zhang, 2021; Evans & Larsen-Freeman, 2020; Zhang et al., 2022).

**Table 1**

*An Overview of the Studies*

| Author(s) | Year | Timespans (months) | Data Point | Skill(s) | Subskill(s) | Data Collection Method | Linguistic measurement | Proficiency | Setting | Participant(s) (number) | L1 | L2/FL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zhang et al. | 2022 | 9 | 30 | Writing | Lexical complexity, syntactic complexity, accuracy, and fluency | Writing tasks with topics from IELTS | Lexical complexity: low-frequency word types/total word types; Syntactic complexity: clauses/T-units; Accuracy: error free T-units/T-units, Fluency: word/T-units | A2 | University students | 22 | Chinese | English |
| Pfenninger | 2022 | 48 to 96 | 16 to 32 | Speaking and writing | Lexical complexity, syntactic complexity, accuracy, and fluency | Writing a timed English narrative and a re-telling oral task | Fluency: written text length and pruned syllables per minute; Complexity: clauses/T-unit and clauses/analysis of speech units (AS-unit); Lexical richness: total word count/total factor count, Accuracy: total number of error-free T-units/AS-units | B2 | 50/50 bilingual school students | 71 | Swiss German | English |
| Rokoszewska | 2022 | 36 | 21 | Writing | Lexical complexity, syntactic complexity, accuracy, and fluency | Written essays during classes | Syntactic complexity: clauses/T-unit; Lexical complexity: complex type-token ratio; Accuracy: correct T-units/all T-units in a text; Fluency: the average number of words/T-units | C1 | Secondary school student | 100 | Polish | English |
| Wind | 2021 | 7 | 7 | Writing | Syntactic and lexical complexity | IELTS type argumentative essays | Lexical complexity: the average word length (AWL) index; Syntactic complexity: finite verb ratio (FVR) | B2 | An IELTS preparatory course student | 6 | Hungarian | English |

| Author(s) | Year | Timespans (months) | Data Point | Skill(s) | Subskill(s) | Data Collection Method | Linguistic measurement | Proficiency | Setting | Participant(s) (number) | L1 | L2/FL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Routarinne & Ahlholm | 2021 | 9 | 48 | Speaking | Making requests | Video-recorded class sessions | Microanalysis of multimodal interaction | B1 | Nine-year-old school student | 1 | Russian | Finnish |
| Gui et al. | 2021 | 4 | 12 | Academmic reading | Academic reading ability in chemistry | Pen and paper test | The test question types: Vocabulary, True or False judgment, Syntactic parsing, Translation from English into Chinese, and Summary | B1 | Chinese chemistry major undergraduates | 27 | Chinese | English |
| Lesonen et al. | 2021 | 9 | 28 to 35 | Speaking and writing | Verbal and adjectival constructs | Writing and talking about chosen topics | Normalized frequencies | A1 | University students | 4 | Varied | Finnish |
| Kliesch & Pfenninger | 2021 | 7 | 30 to 32 | Speaking | Speaking and integrative L2 skills, lexical reception, grammatical reception, fluency, morphosyntactic accuracy, target-like use of lexical items, and lexical richness | Weekly multiple oral and written tests | Integrative L2 Skills: C-test, Lexical reception: odd-one-out task, Grammatical reception: a created test, and oral interviews for Fluency, Morphosyntactic accuracy, Target-like use of lexical items, and Lexical richness | A1 | A 64-year-old learner | 28 | Dutch | Spanish |
| Baba & Nitta | 2021 | 9 | 30 | Writing | Fluency | A timed narrative-writing task | Number of words in an essay | B2 and C1 | University students of an academic writing course | 105 | Japanese | English |

| Author(s) | Year | Timespans (months) | Data Point | Skill(s) | Subskill(s) | Data Collection Method | Linguistic measurement | Proficiency | Setting | Participant(s) (number) | L1 | L2/FL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chang & Zhang | 2021 | 42 | 30 | Listening | Listening performance | IELTS listening tests | IELTS listening test scores | C1 | University students majoring in statistics | 3 | Chinese | English |
| Verspoor et al. | 2021 | 5.5 | 23 | Writing | Syntactic and lexical complexity, and fluency | Short writing tasks | Judgements of ten experience raters; Syntactic complexity: mean length of T-unit; Lexical complexity: Guiraud | Various levels | Secondary school student | 23 | Dutch | English |
| Evans et al. | 2020 | 9 | 30 | Speaking | Syntactic complexity | Narrative tasks and dialogic conversations about daily topics | Analysis of speech units (ASunits): independent clause, or sub-clausal unit together with any subordinate clause(s) associated with either | A2 | A 27-year-old male immigrant | 1 | French | English |
| Casillas | 2020 | 2 | 8 | Pronunciation | Development of Spanish stop voicing contrasts | Delayed repetition and reading | Praat (Voice onset time: the difference (in ms) between the onset of voicing and the burst; Relative voice onset time: the aforementioned VOT value devided by the duration of the CV (stop + vowel) sequence | A1 | 7-week domestic immersion program students | 20 | English | Spanish |
| Huang et al. | 2020 | 9 | 12 | Writing | Complexity, accuracy and fluency | Free writing | Holistic rating (Complexity: sentence structure; Accuracy: correctness of grammar use; Fluency: length of the text within a certain duration of time) | B1 | University students | 2 | Chinese | English |

| Author(s) | Year | Timespans (months) | Data Point | Skill(s) | Subskill(s) | Data Collection Method | Linguistic measurement | Proficiency | Setting | Participant(s) (number) | L1 | L2/FL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fogal | 2020 | 48 | 42 | Writing | Authorial voice (writer, writing situation, disciplinary expectations, genre expectations, Lexico-rhetorical devices, and Dialogism) | University writing tasks | Three informed outside raters using certain developed criteria | C1 | University student in Thailand studying actuary science in English | 1 | Thai | English |
| Khomeijani Farahani et al. | 2020 | 9 | 10 | Writing | Complexity, accuracy and fluency | English textbook writing tasks | Complexity: words/finite verbs ratio; Accuracy: error-free T-unit ratio; Fluency: words/T-unit | B2 | A 17-year-old senior secondary school student | 1 | Farsi | English |
| Rokoszewska | 2020 | 9 | 21 | Speaking | Lexical complexity (lexical density, sophistication, variation, and frequency) | Descriptive and argumentative interviews about the topics covered in the coursebooks | Lexical density: the number of lexical tokens/total number of tokens; Sophistication: the number of more advanced tokens/total number of lexical tokens; Variation: sophisticated or complex type-token ratio (CTTR); Frequency: the percentage of words used by the learner at different frequency levels | "Good, average, and poor" | 16-year-old secondary school learners | 3 | Czech | English |
| Yu & Lowie | 2020 | 4 | 12 | Speaking | Complexity and accuracy | Speaking for 2 to 3 minutes about IELTS Speaking Test topics | Complexity: mean length of speech units in words; Accuracy: number of error-free past tenses and speech units | B2 | College learners of L2 English | 10 | Chinese | English |

| Author(s) | Year | Timespans (months) | Data Point | Skill(s) | Subskill(s) | Data Collection Method | Linguistic measurement | Proficiency | Setting | Participant(s) (number) | L1 | L2/FL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sauer & Ellis | 2019 | 5.5 | 6 | Speaking | Lexical complexity, syntactic complexity, accuracy, and fluency | Semi-structured general personal interviews | Complexity: a)subordination index (SI): average number of clauses/analysis-of-speech-unit (AS-unit), b) mean length of clause: average number of pruned words/clause; Accuracy: a) global accuracy: percentage of error-free clauses, b) specific accuracy: percentage of correct finite verb phrases; Lexis: a) Guiraud's index (GI), b) small words: "small words and phrases, occurring with high frequency in the spoken language; Fluency: speed fluency (speech rate: the number of unpruned words articulated per minute, mean length of run: the number of unpruned words between pauses of 0.3 seconds.), breakdown fluency (empty pauses: the number of silences longer than 0.3 seconds per 100 words, filled pauses: the number of non-lexical fillers (ehm, hmm, eh) per 100 words); repair fluency (repetitions: the number of repeated words per 100 words, reformulations: the number of reformulations of form and content per 100 words) | B1 and B2 | Adolescent learners in Auckland, New Zealand | 2 | German | English |

| Author(s) | Year | Timespans (months) | Data Point | Skill(s) | Subskill(s) | Data Collection Method | Linguistic measurement | Proficiency | Setting | Participant(s) (number) | L1 | L2/FL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lowie & Verspoor | 2019 | 7 | 23 | Writing | Syntactic and lexical complexity | Free writing tasks related to participants' lives or class topics | Experienced raters and analytical measures (Syntactic complexity: the mean length of T-Unit and the number of dependent clauses/T-unit; Lexical complexity: mean length of word and Giraud; Complexity of noun phrases: the number of dependents/nominal in noun phrases) | B1 and B2 | Secondary schoold students | 22 | Dutch | English |
| Menke & Strawbridge | 2019 | 33 | 11 to 17 | Academic writing | Syntactic complexity in academic discourse | Written assignments completed during the major | Length-based measurement: a)mean length of clause, b) mean length of T-unit, c)mean length of noun; Inter-clausal relationship indices: a)clauses / T-unit, b)grammatical intricacy, c)simple sentence ratio; Phrasal/clausal variety: a)noun phrase accessibility hierarchy, b)noun phrase modification types | B1 | University students of a Spanish major program | 3 | English | Spanish |
| Bulté & Housen | 2018 | 19 | 11 | Writing | Syntactic complexity | Writing tasks about chosen topics | Mean length of T-unit, subclause ratio (subclauses/clauses), Coordinate clause ratio (coordinate clauses/sentences), Mean length of finite clause (word tokens/finite clauses), Mean length of noun phrase (word tokens in NPs/NPs) | A1 and A2 | Secondary school students | 10 | Dutch | English |

| Author(s) | Year | Timespans (months) | Data Point | Skill(s) | Subskill(s) | Data Collection Method | Linguistic measurement | Proficiency | Setting | Participant(s) (number) | L1 | L2/FL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lowie et al. | 2017 | 8 | 100 | Speaking and writing | Syntactic and lexical complexity | Speaking and writing tasks (TOEFL topics) | Syntactic complexity: mean length of T-units; lexical diversity, VocD (which is an adjusted metric for the type or token ratio) | A2 | Identical 15-year-old twins | 2 | Chinese | English |
| Verspoor et al. | 2017 | 48 | 22 | Writing | Syntactic and lexical complexity | Academic papers | General (lexical: average word length, syntactic: finite verb ratio) and specific (lexical: finite adverbial, nominal and relative clauses, syntactic: non-finite constructions) | C1 | University students | 3 | Dutch | English |
| Zheng | 2016 | 10 | 8 | Writing | Lexical complexity | Academic writing tasks | Uber's index (lexical diversity), VocabProfile software (the frequency-based lexical measures), AntConc (searching the target bundles) | B2 | First-year university students enrolled in an English major program | 15 | Chinese | English |
| Vyatkina et al. | 2015 | 21 | 17 | Writing | Syntactic complexity | Writing essays as curricular tasks | ANNIS (used for prenominal (attributive) adjectives, cardinal numbers, predicative and adverbial adjectives, adverbs) | A1 | University students enrolled in a basic German language program | 12 | English | German |
| Eskildsen | 2015 | 24 | 5 | Speaking | Yes/no and WH interrogatives | Audio-visual recordings of classroom interaction | Qualitative categorization and analysis | A1 | University students | 2 | Spanish | English |

| Author(s) | Year | Timespans (months) | Data Point | Skill(s) | Subskill(s) | Data Collection Method | Linguistic measurement | Proficiency | Setting | Participant(s) (number) | L1 | L2/FL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chan et al. | 2015 | 8 | 100 | Speaking and writing | Syntactic complexity | Oral and written tasks (topics selected from TOEFL tests) | Mean length of T-unit, Dependent clauses/T-unit, Coordinate phrases/T-unit | A2 | Identical twins | 2 | Taiwanese | English |
| Baba & Nitta | 2014 | 9 | 30 | Writing | Writing fluency | Compositions as assignments | The total number of words in a composition | A2 and B1 | University students | 2 | Japanese | English |
| Kowal | 2014 | 33 | 6 | Writing | Writing fluency | Writing narratives of personal experiences | Mean transition time, Mean length of burst | A1 | University students | 15 | Polish | Swedish |
| Rosmawati | 2014 | 4 | 10 | Writing | Complexity and accuracy | Academic argumentative essays on TOEFL topics | Complexity: word/finite verb, Accuracy: error-free clause/clause | C1 | A post-graduate student in Australia | 1 | Japanese | English |
| Polat & Kim | 2014 | 12 | 24 | Speaking | Lexical complexity, syntactic complexity, and accuracy | Unstructured friendly interviews | Syntactic complexity: mean length of AS-units, clauses/AS-unit, mean length of clauses; Lexical diversity: D; Accuracy: errors/100 words | C1 | An untutored immigrant | 1 | Turkish | English |
| Zhang & Lu | 2013 | 4 | 6 | Writing | Chinese numeral classifier system (fluency, diversity, and accuracy) | Written essays (coursbook topics) | Fluency: number of classifier tokens or types/hundred characters, Diversity: type–token ratio of classifiers, Accuracy of produced classifiers: accuracy rate of classifiers produced by learners, Accuracy of classifiers in obligatory environments: accuracy rate of classifiers in all obligatory environments | B1 and B2 | University students | 87 | English | Chinese |

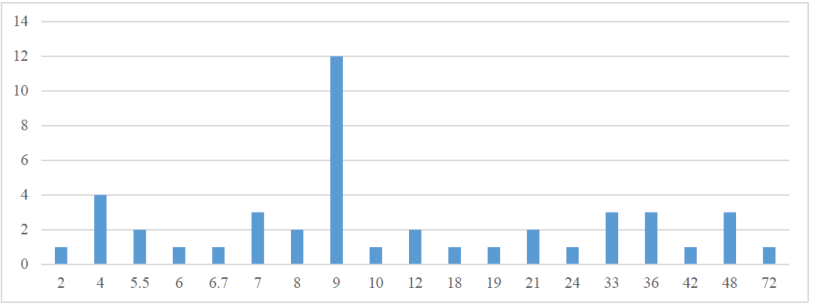
| Author(s) | Year | Timespans (months) | Data Point | Skill(s) | Subskill(s) | Data Collection Method | Linguistic measurement | Proficiency | Setting | Participant(s) (number) | L1 | L2/FL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Caspi & Lowie | 2013 | 9 | 36 | Writing | Academic vocabulary recognition, recall, controlled and free production | Longitudinal Academic Vocabulary Tests (LAVT) and written essays | Recognition, recall, and controlled production: the Longitudinal Academic Vocabulary Tests (LAVT), Free production: the ratio of correct academic (UWL and AWL) word families to the total number of academic word tokens divided by the total number of correct content words and multiplied by the general family or token ratio | C1 | A university student | 1 | Portuguese | English |
| Vyatkina | 2012 | 21 | 19 | Writing | Complexity | Curricular writing tasks | General complexity: words/sentence (sentence length); Clausal complexity: clauses/sentences and words/clauses; Coordination and subordination: normalized coordinating conjunctions and subordinating conjunctions frequencies/100 words; Lexicogrammatical variety: type–token ratio | A1 | University students | 2 | English | German |
| Spoelman & Verspoor | 2010 | 36 | 54 | Writing | Complexity and accuracy | Writing samples on academic topics | Accuracy: the difference between the total number of cases and the number of incorrect cases divided by the total number of cases, Word complexity: the average sentence length in morphemes and the average sentence length in words, NP complexity: averaging NP length in words, Sentence complexity: averaging number of dependent clauses per text | A1 | A theoretical linguistics university student who took a minor in Finnish | 1 | Dutch | Finnish |

| Author(s) | Year | Timespans (months) | Data Point | Skill(s) | Subskill(s) | Data Collection Method | Linguistic measurement | Proficiency | Setting | Participant(s) (number) | L1 | L2/FL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eskildsen | 2009 | 48 | 40 | Speaking | Usage of "can" | Audio-visual recordings of classroom interaction | Qualitative and manual measurement | A1 | Language school students | 1 | Spanish | English |
| Li & Schmitt | 2009 | 9 | 9 | Writing | Lexical phrases development and appropriateness | Academic writing essays | The judgement of a panel of raters | B2 | An MA student in English Language Teaching program | 1 | Chinese | English |
| Munro & Derwing | 2008 | 12 | 6 | Pronunciation | Vowel intelligibility | Delayed repetition task | The judgement of four phonetically trained Canadian judges | A1 | Immigrants in an ESL program | 44 | Chinese and Slavic | English |
| Mellow | 2008 | 6.7 | 15 | Writing | Complexity: acquisition of resolutions of the argument dependencies of verbs | Written narratives summarizing wordless picture books | Judgements of raters | A2 | 12-year-old immigrant school student | 1 | Spanish | English |
| Serrano & Howard | 2007 | 33 | 9 | Writing | Composition, grammar, and mechanics | Free narrative writing assignments | A developed analytic rubric: Composition (topic development, sentence formation, supporting details, descriptive language), Grammar (verbs, agreement, placement, prepositions), Mechanics (spelling, punctuation, capitalisation, paragraph formation) | B2 | Language school children students | 2 | Spanish/ English | English/ Spanish |

| Author(s) | Year | Timespans (months) | Data Point | Skill(s) | Subskill(s) | Data Collection Method | Linguistic measurement | Proficiency | Setting | Participant(s) (number) | L1 | L2/FL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Larsen-Freeman | 2006 | 6 | 4 | Speaking and writing | Lexical complexity, syntactic complexity, accuracy, and fluency | Writing a narrative about a past episode and telling the stories orally | (In addition to qualitative analysis) Grammatical complexity: average number of clauses/T-unit, Vocabulary complexity: word types/square root of two times the words, Accuracy: the proportion of error-free T-units to T-units, Fluency: average number of words/T-unit | B2 | Immigrants | 5 | Chinese and Slavic | English |
| Zhang | 2004 | 9 | 9 | Speaking | Adjective marker -de in Chinese | Free-production speech samples | Emergence criterion (the adjective suffix -de(ADJ) was viewed as having emerged if there were a minimum of four tokens of it in a sample set), qualitative analysis. | A1 | University students | 3 | English | Chinese |
| Skiba & Dittmar | 1992 | 36 | 21 | Speaking | Morphosyntactic development and grammaticalization | Video and cassette recordings | Qualitative measurement in addition to valency and co-occurrence of expressions | A1 | Immigrants | 3 | Polish | German |
| Hanania & Gradman | 1977 | 18 | 18 | Speaking | General development | Tape-recorded conversations | Qualitative measurement of numerous linguistic components | A1 | An immigrant | 1 | Arabic | English |

**Figure 3**

*The Frequencies of Timespans*




## Participants and Settings

Figure 5 illustrates the number of participants in the reviewed studies. Although in two of the studies one hundred or more participants were examined (Baba & Nitta, 2021; Rokoszewska, 2022), these are rare cases in the realm of longitudinal CDST investigations of second language development. More than half of the studies had at most three participants whose second language developmental patterns were tracked. A considerable portion of the studies focused on the second language development of only one participant. Regarding the background of the participants (Figure 6), 22 studies examined university students. Next, school students, such as high school, secondary school and elementary school students (in ten studies), and immigrants (in six studies) comprised the biggest portion of the studied participants. Two of the papers studied the second language developmental patterns of identical twins with the aim of having a clearer comparison between participants and minimizing the impact of extraneous variables on second language development as much as possible (Chan et al., 2015; Lowie et al., 2017).

**Figure 4**

*The Frequencies of Data Points*

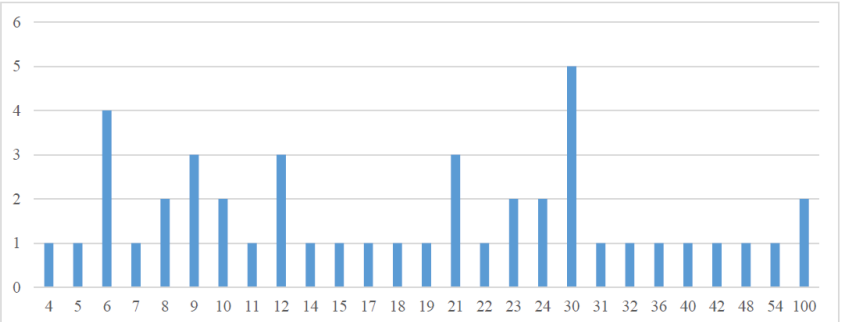
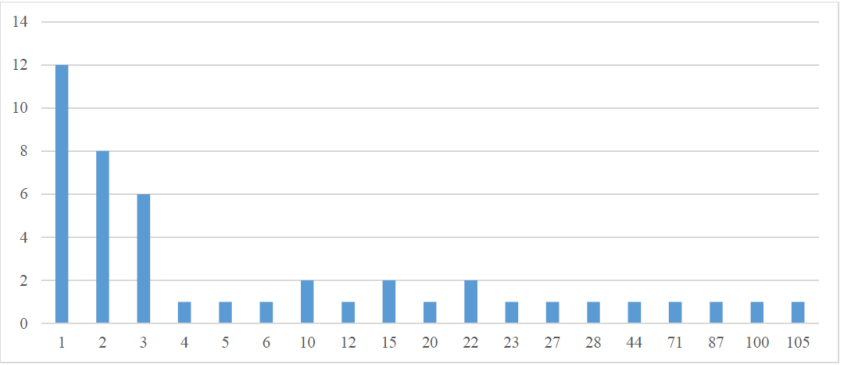


**Figure 5**

*The Frequencies of Number of Participants*




The participants of the reviewed studies had different first languages (Figure 7). Chinese (21%), English (15%), and Dutch (13%) were the most observed first languages. However, the second languages that the participants were learning were not so different (Figure 8). In more than two thirds of the studies, English was the language that participants were learning. The other learned second languages included Spanish, German, Finnish, Chinese, and Swedish. Among the 45 papers, 37 mentioned the second language proficiency levels of their participants. Figure 9 shows the distribution of participants' level of proficiency in the reviewed studies. The biggest portion of the studies were focused on dynamic second language development of participants at beginner (A1) proficiency level.

**Figure 6**

*The Frequency of Contexts*

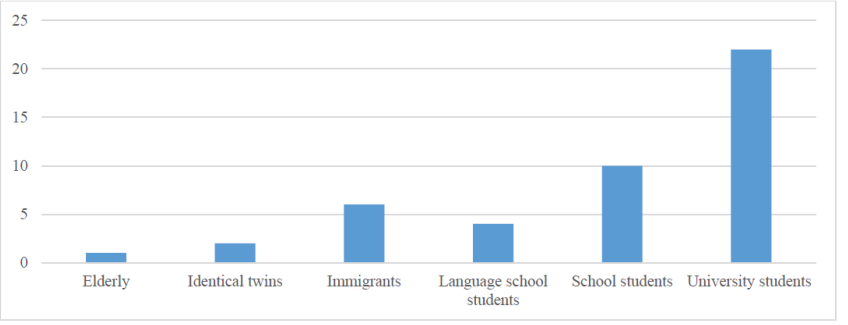


**Figure 7**

*The Frequency of Participants' First Languages*

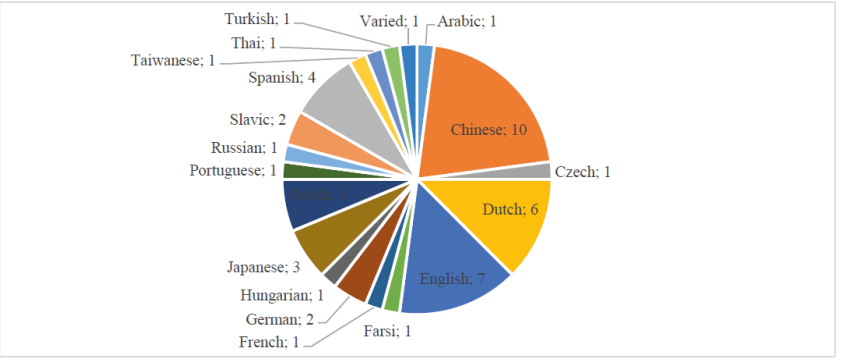



**Figure 8**

*The Frequency of Participants' Second or Foreign Languages*

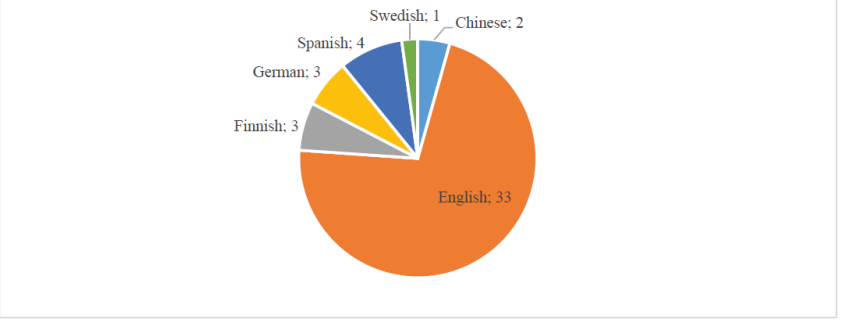
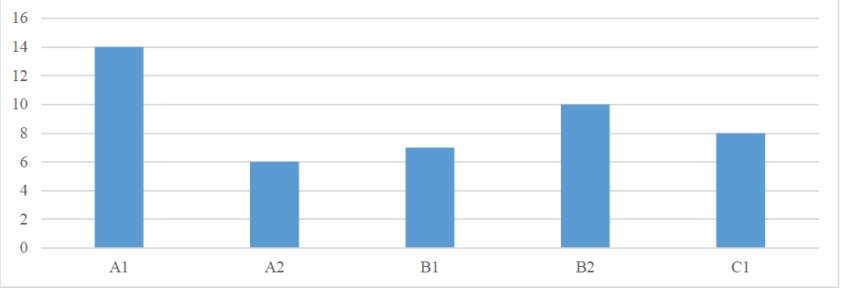



**Figure 9**

*The Frequency of Participants' Level of Proficiency*

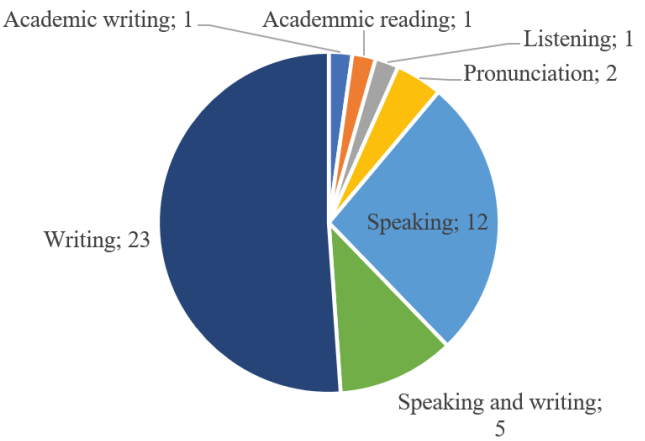


## Language Skills, Data Collection Methods

More than half of the studies used writing in order to observe the developing trend of second languages among participants. Speaking, and a combination of speaking and writing were respectively 11 and five times the focus of the reviewed studies. Only five studies were dedicated to the dynamic second language development of other language skills and subskills, including pronunciation, listening, academic reading, and academic writing. The fact that the development of a newly learned language can be more accurately traced in the production of utterances (as opposed to receiving utterances) explains the considerably abundant writing and speaking studies in comparison with the reading and listening ones. It should also be noted that in some studies the aim was to investigate the development of specific grammar structures while speaking or writing were just ways through which the structures were investigated. For example, Eskildsen (2015), Eskildsen (2009), and Zhang (2004) attempted to keep track of the development of interrogatives, use of the modal verb "can," and adjective makers respectively. Figure 10 illustrates the proportions of each language skill among the reviewed papers.

**Figure 10**

*The Portions of Examined Language Skills*




A variety of ways were adopted to collect data from the participants (Table 2). In order to examine the development of participants' writing, the studies utilized class writing tasks, academic writing samples, and narratives essays in addition to writings about chosen topics, TOEFL topics, and IELTS topics. The studies focused on spoken language of the participants utilized interviews, recorded speech, narratives, and tasks about IELTS and TOEFL topics. As a technique that requires participants to repeat words and phrases

after hearing them, delayed repetition was used by Munro and Derwing (2008) for collection of data on participants' pronunciation. This method was combined with reading out loud in Casillas (2020). As the only two studies which focused on the developmental patterns of receptive skills, Gui et al. (2021) and Chang and Zhang (2021) used a pen and paper and IELTS listening tests respectively to investigate their participants' development in academic reading and listening.

## Subsystems and Measurement

Table 3 presents an overview of the subsystems which were investigated in the reviewed papers. Complexity (both syntactic or lexical), accuracy, and fluency (CAF), as three central aspects of language used for measuring second language development (Barrot & Agdeppa, 2021), have been the most commonly investigated facets of language production in the reviewed papers. Among the 41 studies where the development of writing and speaking were investigated, 28 kept track of the development of at least one of CAF elements. The rest of the examined subsystems include academic vocabulary, linguistic constructs, and interrogatives. The measurements utilized for each subsystem in each study can also be seen Table 1.

## General Observations

All of the reviewed papers reported findings that were supportive of the CDST principles in second language development. Inter- and intra-individual variability, non-linearity, and dynamicity were the characteristics that the 45 reviewed articles repeatedly used to describe the developmental patterns of the different examined subsystems among learners. It should also be noted that 20 papers reported the existence of at least some degree of similarities between how the examined subsystems developed among learners. Such similarities included general developmental trends, second language trajectories, and learning prototypes. The detection of such similarities does not contradict the dynamicity and variability of second language development since only some aspects of developmental patterns were reported to follow regularities. Finally, a few studies reported the significant role of individual characteristics like age and level of proficiency in second language developmental patterns.

**Table 2**

*Data Collection Methods among Language Skills*

| Skills | Data collection methods | Count |
|---|---|---|
| Writing | | |
| | Academic writings | 4 |
| | Free writing | 2 |
| | Writing about specified topics | 6 |
| | Writing about TOEFL topics | 3 |
| | Writing narratives | 6 |
| | Writing tasks IELTS | 2 |
| | Written class essays | 6 |
| Reading | | |
| | Pen and paper test | 1 |
| Listening | | |
| | IELTS listening test | |
| Speaking | | |
| | Interviews | 4 |
| | Recorded speech | 5 |
| | Speaking about IELTS topics | 1 |
| | Speaking about specified topics | 1 |
| | Speaking about TOEFL topics | 2 |
| | Telling narratives | 3 |
| Pronunciation | | |
| | Delayed repetition and reading | 1 |
| | Delayed repetition | 1 |

**Table 3**

*The Examined Subsystems among Language Skills*

| Skills | The examined subsystems | Count |
|---|---|---|
| Writing | | |
| | Academic vocabulary recognition, recall, controlled and free production | 1 |
| | Authorial voice | 1 |
| | CAF | 2 |
| | Chinese numeral classifier system (fluency, diversity, and accuracy) | 1 |
| | Complexity | 1 |

| | | |
|---|---|---|
| | Complexity and accuracy | 2 |
| | Complexity: acquisition of resolutions of the argument dependencies of verbs | 1 |
| | Composition, grammar, and mechanics | 1 |
| | Fluency | 3 |
| | Lexical complexity | 1 |
| | Lexical complexity, syntactic complexity, accuracy, and fluency | 2 |
| | Lexical phrases development and appropriateness | 1 |
| | Syntactic and lexical complexity | 3 |
| | Syntactic and lexical complexity, and fluency | 1 |
| | Syntactic complexity | 3 |
| Speaking | | |
| | Adjective marker -de in Chinese | 1 |
| | Complexity and accuracy | 1 |
| | General development | 1 |
| | Lexical complexity | 1 |
| | Lexical complexity, syntactic complexity, accuracy, and fluency | 1 |
| | Lexical complexity, syntactic complexity, and accuracy | 1 |
| | Making requests | 1 |
| | Morphosyntactic development and grammaticalization | 1 |
| | Speaking and integrative L2 skills | 1 |
| | Syntactic complexity | 1 |
| | Usage of "can" | 1 |
| | Yes/no and WH interrogatives | 1 |
| | Speaking and writing | |
| | Lexical complexity, syntactic complexity, accuracy, and fluency | 2 |
| | Syntactic and lexical complexity | 1 |
| | Syntactic complexity | 1 |
| | Verbal and adjectival constructs | 1 |
| Listening | | |
| | General listening performance | 1 |
| Reading | | |
| | Academic reading ability in chemistry | 1 |
| Pronunciation | | |
| | Development of Spanish stop voicing contrasts | 1 |
| | Vowel intelligibility | 1 |

## Discussion

The two research questions that this review has attempted to investigate were focused on the methodological characteristics, and also the patterns of findings in previous CDST studies in the field of second language development. Regarding the first research question, most of the studies were expectedly focused on productive language skills (speaking and writing) as their development can be more easily measured and traced. More than half of the papers examined the development of at least one of the CAF subsystems. Abundance of data points and lengthier timespans were other expected characteristics which were observed. The biggest portion of the studies (73%) had participants who were either university students or school students. Additionally, the participants in 14 studies were at beginner level with respect to the second language they were acquiring.

To address the second research question, the observations of the 45 reviewed studies conclusively support the dynamicity of second language development. The studies tracked the development of participants with various characteristics from different backgrounds and also in different contexts and, although some general regularities and patterns were seen, all of the studies were supportive of the CDST view in second language development. Consistently, patterns of participants' second language development were indicative of within and between individual variability. Patterns of development were non-linear and various between and within participants. The examined subsystems showed interconnectedness as well. The innumerable individual and extraneous variables that impact second language acquisition make this development a dynamic one. A few of such variables include affect, motivation, environmental factors (Khomeijani et al., 2020; Zhang et al., 2022), age of onset (Pfenninger, 2022), first language fluency, individual learner investment, amount of available free time, and competition among learners (Kliesch & Pfenninger, 2021).

While the majority of the reviewed studies were focused on development of subsystems (especially complexity, accuracy, and fluency) in writing and speaking, the dynamic nature of second language development was also supported in the few studies which were focused on the receptive language skills (reading and listening). Keeping track of the reading ability gains of 27 English learners 12 times over an academic semester, Gui et al. (2021) observed that the development among the learners was individual and non-linear. The performance of three Chinese learners of English in IELTS listening tests during 3.5 years was also supportive of the dynamicity of second language listening development in Chang and Zhang (2021).

Among the reviewed papers, two separate studies attempted to investigate and compare second language development among identical twins (Chan et al.,

2015; Lowie et al., 2017). Consistent with CDST, the findings of both studies showed that second language acquisition is idiosyncratic and patterns of development and even the degree of variability changed from twin to twin. The study conducted by Wind (2021) showed that even the development of self-reflection was individual and dynamic. The development of phonetic skills was similarly shown as dynamic and non-linear in Munro and Derwing (2008) and Casillas (2020).

Some of the studies have found ways of roughly categorizing the dynamic development of learners. In the research conducted by Zhang et al. (2022), three different prototypical patterns were observed, which included three groups of participants: participants with continuous stable development, participants with initial fluctuating development followed by steady development, and participants with constant fluctuating developmental patterns. Similarly, general patterns of development were shared among three groups of participants in Baba and Nitta (2021). Examining the narrative writing tasks of university students, collected 30 times over an academic year, showed three general developmental patterns including a stagnating, steadily growing, and markedly growing patterns. A number of common syntactic and lexical developmental patterns were also revealed among learners in Verspoor et al. (2021).

The two studies which focused on the age of second language learners, in different settings, did not find congruent findings. Among the 71 examined participants, Pfenninger (2022) observed that the ones who started learning English at the age of seven gained higher degrees of proficiency with different second language trajectories in comparison with the participants who started learning when they were nine years of age. Nevertheless, the study conducted by Kliesch and Pfenninger (2021) which tested 28 participants over the age of 64 did not show any significant impact of age and even some older participants performed better than their younger peers.

Different directions of development were observed with respect to the language subsystems in the course of second language acquisition. The development of CAF subsystems were reported to have different and inconsistent directions, fluctuating between supportive and competitive at different stages (Evans & Larsen-Freeman, 2020; Spoelman & Verspoor, 2010; Yu & Lowie, 2020; Wind, 2021; Zhang et al., 2022). Zhang et al. (2022) observed that accuracy had trade-off effects with the other subsystems (complexity and fluency). The study conducted by Rokoszewska (2022) was indicative of negative associations between the development of the syntactic and lexical complexity, accuracy, and fluency, while supportive within-subsystem relationships were observed (e.g., subordination, coordination, and nominalization). The varied and flexible associations between the development of linguistic subsystems are indicative of the interconnectedness as a characteristics of complex and dynamic systems.

An interesting observation which was reported several times is that more variability and fluctuation in second language development seems to correlate with increased proficiency (Gui et al., 2021; Huang et al., 2021; Lesonen, 2021). The study conducted by Zhang et al. (2022) showed that among the three prototypes of learners, the prototype with constant variability in the development had more overall progress compared to the other prototypes. Among the two remaining ones, the participants with only initial variability had improved more than the participants with constant steady developmental patterns. The correlation between variability and linguistic ability gains was also observed in the only study that focused on reading in second language development (Gui et al., 2021). In addition, variability was positively related with the measures of aptitude, motivation, and exposure in Lowie and Verspoor (2019). Moreover, Kliesch and Pfenninger (2021), Khomeijani et al. (2020), Spoelman and Verspoor (2010), and Bulté and Housen (2018) observed that the association between variability and second language development was strongest at lower levels of proficiency and it seemed to wane when certain degrees of progress occurred. Lower degrees of variability was also negatively associated with second language development among the examined identical twins in Lowie et al. (2017). Even in the development of pronunciation subskills, Munro and Derwing (2008) observed that more changes occurred during the initial stages of participants' developmental patterns and the variability decreased as participants grew more proficient in their pronunciation.

## Future Research

While previous findings are incontrovertibly indicative of the fact that second language development is dynamic, the next steps that need to be taken seem to be finding potential regularities, establishing dynamic models for second language development, and testing for optimized learning methods and activities in accordance with potentially predictable developmental patterns. From the perspective of CDST, second language learning is unpredictable although not random (Larsen-Freeman & Cameron, 2008). However, considering other complex systems, it can be observed that the unpredictability and uncertainty of complex systems are more pronounced in the long term. Different tools and methods have been established to investigate complex systems in different realms such as biology (Karr et al., 2012), climate science (Lau & Ploshay, 2013), chemistry (Lewars, 2011), and physics (Holovatch et al., 2017). Comparably, complex systems have not been sufficiently examined in agent-based systems where autonomous decision-making agents like people

exist (An et al., 2021; Hilpert & Marchand, 2018; Schulze et al., 2017). It is a shortcoming which stems from the fact that traditional mathematical modeling is significantly more difficult for agent-based systems. A new line of research can be the pursuit of appropriate mathematical models and analyses for approximate prediction of patterns and trends of second language development. As an example of the symptoms that can potentially predict the short-term trend of development, Evans and Larsen-Freeman (2020) observed that phases of instability, characterized by increase in the flow disruptions and also production bimodality, were indicative of phase shifts in the developmental patterns of their participants. More studies can attempt to identify trends in the dynamic development of second languages, like Zhang et al. (2022) and Baba and Nitta (2021) where three prototypes for individual learning patterns were observed. Additionally, Gui et al. (2021) reported seven developmental patterns among the reading development of participants over time.

In addition to providing deeper theoretical understanding about the dynamic patterns of second language development, being able to roughly predict these patterns has numerous implications. For example, considering the ups and downs and phase shifts that a learner experiences in their development of second language speaking subskills, being able to predict the short-term developmental fluctuations can help them set their IELTS speaking exam at a peak of this pattern of speaking development. While CDST emphasizes the uniqueness of language acquisition for each learner (Lesonen, 2021), attempting to find regularities in second language development is of great importance (Dornyei, 2014; Ellis, 2007; Lowie & Verspoor, 2019; Pfenninger, 2022; Zhang, 2022). Bulté and Housen (2018) propose the utilization of true dynamic methods and adding mathematical models in future studies. Leveraging big data, future studies can benefit from computational linguistics and data science for further investigation of the dynamic development of second language. They can also open the doors for future studies focused on adopting targeted instructions and feedback which would optimize second language development of learners.

There is a number of other issues on which future research can shed more light. While some previous studies have revealed that more variability in second language development leads to higher degrees of proficiency (Kliesch & Pfenninger, 2021; Lesonen, 2021), future studies specifically focused on this relationship can show the significance of such a correlation. Munro and Derwing (2008), Kliesch and Pfenninger (2021), Spoelman and Verspoor (2010), and Khomeijani et al. (2020) observed that the association between variability and proficiency gains is stronger at lower proficiency levels. Future experiments can clarify the waning of such correlation at higher proficiency levels.

A specific question that can be pursued is the degree of dynamicity in the development of different linguistic subsystems. As an example, Kliesch and Pfenninger (2021) observed that the group developmental pattern of fluency bet-

ter presented the individual trajectories of the participants in comparison with that of lexical richness. Also, another subject which needs further investigation are the relationships and interactions between different language subsystems during second language development (especially syntactic and lexical complexity). Different associations with variable directions have been reported in the literature (Khomeijani et al., 2020; Rokoszewska, 2022; Spoelman & Verspoor, 2010; Yu & Lowie, 2020; Zhang et al., 2022). Examining the existence of such supportive or competitive associations between and within the subsystems can further clarify them. The rate and speed comparisons of development in CAF subsystems can be another issue requiring further examination. Verspoor et al. (2017) emphasized the need for different linguistic measures for different proficiency levels in order to increase the accuracy of developmental measurements.

Comparing dynamic second language development between different ages, different L1 fluency levels, and different levels of second language proficiency are other topics which have not received specific but sporadic attention in the literature. Since initial states of complex systems can strongly influence the long-term conditions of these systems (an impact also known as the butterfly effect), the aforementioned learner characteristics can considerably impact the progression and outcome of second language acquisition. In addition, a number of previous studies have mentioned task effect an extraneous variable the impact of which could not be controlled (Lesonen et al., 2021; Menke and Strawbridge, 2019; Vyatkina et al., 2015). Controlling for this factor can add to the accuracy of the observations in future research. The effects of targeted feedback can also be tested on the subsystems with slower developing subsystems (Rokoszewska, 2022). Another issue is the summer gaps that occurred during the data collection of studies which examined the development of students during academic years. Such gaps stop the continuous tracking of participants' developmental patterns and can be delimited in future studies.

While the acquisition and development of specific second language subsystems, especially complexity accuracy and fluency, has been repeatedly investigated, few studies have focused on development of other aspects of second language (such as the use of "can," authorial voice, and interrogatives). Future research can delve into the development of such other subsystems from the CDST viewpoint. Additionally, the development of listening and reading has not received sufficient attention since only two studies (Chang & Zhang, 2021; Gui et al., 2021) have examined second language development in receptive language skills. Future studies can alleviate the shortage in this realm.

## Conclusion

From the perspective of CDST, second language development is a unique and different process for every single person. The present systematic literature review has attempted to examine previous studies which examined second language development from CDST viewpoint. The main three goals of this review were presenting an overview of the methodological characteristics of the previous studies in the field, providing a synthesis of their findings, and identifying the gaps and areas which require further investigation in future studies. The searching strategy of this review led to finding 45 articles in the literature. Since CDST studies need keeping track of learners' linguistic development over longer periods of time in a detailed manner, longitudinal design and abundance of data points were the two important characteristics of the reviewed papers. Speaking and writing were the most investigated skills, while complexity, accuracy, and fluency were the most examined subsystems. The observations of all of the reviewed papers supported the CDST principles in second language development. The reports indicated that developmental patterns were non-linear and variable between and within participants. A number of repeated, but yet inconclusive correlations were observed. Increased fluctuations in developmental patterns of a subsystem were associated with more development of that subsystem. Moreover, developmental fluctuations seem to decrease as a learner becomes more proficient. While such issues require further examination, other important areas which require research are modeling the dynamic development of second languages and searching for potential regularities, prototypes, and trajectories.

## References

An, L., Grimm, V., Sullivan, A., Turner II, B., Malleson, N., & Heppenstall, A. et al. (2021). Challenges, tasks, and opportunities in modeling agent-based complex systems. *Ecological Modelling, 457*, 109685. https://doi.org/10.1016/j.ecolmodel.2021.109685

Baba, K., & Nitta, R. (2014). Phase transitions in development of writing fluency from a complex dynamic systems perspective. *Language Learning, 64*(1), 1–35. https://doi.org/10.1111/lang.12033

Baba, K., & Nitta, R. (2021). Emergence of multiple groups of learners with different writing-development trajectories in classroom: Growth mixture modeling. *Journal of Second Language Writing, 54*, 100856.

Bak, T. H., Long, M. R., Vega-Mendoza, M., & Sorace, A. (2016). Novelty, challenge, and practice: The impact of intensive language learning on attentional functions. *Plos One, 11*, e0153485.

Bastardas-Boada, A. (2013). Language policy and planning as an interdisciplinary field: Towards a complexity approach. *Current Issues in Language Planning, 14*(3–4), 363–381.

Berggren, R., Nilsson, J., Brehmer, Y., Schmiedek, F., & Lövdén, M. (2020). Foreign language learning in older age does not improve memory or intelligence: Evidence from a randomized controlled study. *Psychology and Aging, 35*(2), 212–219.

Blommaert, J. (2014). From mobility to complexity in sociolinguistic theory and method. *Tilburg Papers in Culture Studies, 103*, 1–24.

de Bot, K., & D. Larsen-Freeman (2011). Researching second language development from a dynamic systems theory perspective. In M. H. Verspoor et al. (Eds.), *A dynamic approach to second language development* (pp. 5–23). Benjamins.

de Bot, K., W. Lowie, & M. Verspoor (2007). A Dynamic Systems Theory approach to second language acquisition. *Bilingualism: Language and Cognition, 10*(1), 7–21.

Bulté, B., & Housen, A. (2018). Syntactic complexity in L2 writing: Individual pathways and emerging group trends. *International Journal of Applied Linguistics, 28*(1), 147–164.

Casillas, J. V. (2020). The longitudinal development of fine-phonetic detail: Stop production in a domestic immersion program. *Language Learning, 70*, 768–806. https://doi.org/10.1111/lang.12392

Caspi, T., & Lowie, W. M. (2013). The dynamics of L2 vocabulary development: A case study of receptive and productive knowledge. *Revista Brasiliera de Linguistica, 13*(2), 437–462.

Chan, H., Verspoor, M., & Vahtrick, L. (2015). Dynamic development in speaking versus writing in identical twins. *Language Learning, 65*, 298–325.

Chang, P., & Zhang, L. J. (2021). A CDST perspective on variability in foreign language learners' listening development. *Frontiers in Psychology, 12*(601962), 1e14. https://doi.org/10.3389/fpsyg.2021.601962

Dörnyei, Z. (2014). Researching complex dynamic systems: 'Retrodictive qualitative modelling' in the language classroom. *Language Teaching, 47*, 80–91.

Ellis, N. C. (2007). Dynamic systems and SLA: The wood and the trees. *Bilingualism: Language and Cognition, 10*(1), 23–25.

Eskildsen, S. W. (2009). Constructing another Language—Usage-Based Linguistics in Second Language Acquisition. *Applied Linguistics, 30*(3), 335–357. http://doi.org/10.1093/applin/amn037

Eskildsen, S. W. (2015). What counts as a developmental sequence? Exemplar-based L2 learning of English questions. *Language Learning, 65*(1), 33–62.

Evans, D. R., & Larsen-Freeman, D. (2020). Bifurcations and the emergence of L2 syntactic structures in a complex dynamic system. *Front. Psychol. 11*, 574603. http://doi.org/10.3389/fpsyg.2020.574603

Fogal, G. G. (2020). Investigating variability in L2 development: Extending a complexity theory perspective on L2 writing studies and authorial voice. *Applied Linguistics, 41*(4), 575–600. http://doi.org/10.1093/applin/amz005

Fogal, G. G., & Koyama, D. (2022). A study of co-adaptation through journaling. *Journal of Second Language Writing, 55*, 100873.

Gui, M., Chen, X., & Verspoor, M. (2021). The dynamics of reading development in L2 English for academic purposes. *System, 100*, 102546. http://doi.org/10.1016/j.system.2021.102546

Han, J., & Hiver, P. (2018). Genre-based L2 writing instruction and writing-specific psychological factors: The dynamics of change. *Journal of Second Language Writing, 40*, 44–59.

Han, Z. (2021). Usage-based instruction, systems thinking, and the role of Language Mining in second language development. *Language Teaching, 54*(4), 502–517. https://doi.org/10.1017/S0261444820000282

Hanania, E. A., & Gradman, H. L. (1977). Acquisition of English structures: A case study of an adult native speaker of Arabic in an English-speaking environment. *Language Learning, 27*, 75–91. https://doi.org/10.1111/j.1467-1770.1977.tb00293.x

Hilpert, J. C., & Marchand, G. C. (2018). Complex systems research in educational psychology: Aligning theory and method. *Educational Psychologist, 53*(3), 185–202.

Hiver, P., & Al-Hoorie, A. H. (2016). A dynamic ensemble for second language research: Putting complexity theory into practice. *The Modern Language Journal, 100*(4), 741–756.

Hiver, P., Al-Hoorie, A. H., & Evans, R. (2022). Complex dynamic systems theory in language learning: A scoping review of 25 years of research. *Studies in Second Language Acquisition, 44*(4), 913–941.

Holovatch, Y., Kenna, R., Thurner, S. (2017). Complex systems: Physics beyond physics. *European Journal of Physics, 38*, 023002. https://doi.org/10.1088/1361-6404/aa5a87

Huang, T., Steinkrauss, R., & Verspoor, M. (2022). Learning an L2 and L3 at the same time: Help or hinder?. *International Journal of Multilingualism*, *19*(4), 566–582. https://doi.org/10.1080/14790718.2020.1779726

Hult, F. (2010). The complexity turn in educational linguistics. *Language, Culture and Curriculum, 23*, 173–177.

Karr, J. R., Sanghvi, J. C., Macklin, D. N., Gutschow, M. V., Jacobs, J. M., Jr. Bolival, B., Assad-Garcia, N., Glass, J. I., Covert, M. W. (2012). A whole-cell computational model predicts phenotype from genotype. *Cell, 150*, 389–401. https://doi.org/10.1016/j.cell.2012.05.044.

Khomeijani Farahani, A. A., Rezaee, A. A., & Moshtaghi Zonouz, R. (2020). Exploring the development of writing complexity, accuracy, and fluency in relation to the motivational trajectories: a dynamically-oriented case study. *English Teaching & Learning, 44*(1), 81–100.

Kliesch, M., & Pfenninger, S. E. (2021). Cognitive and socioaffective predictors of L2 microdevelopment in late adulthood: A longitudinal intervention study. *The Modern Language Journal, 105*(1), 237–266. https://doi.org/10.1111/modl.12696

Kowal, I. (2014). Fluency in second language writing: A developmental perspective. *Studia Linguistica Universitatis Iagellonicae Cracoviensis, 131*(2014), 229–246. https://doi.org/10.4467/20834624SL.14.013.2321

Kramsch, C., & Whiteside, A. (2008). Language ecology in multilingual settings. Towards a theory of symbolic competence. *Applied Linguistics, 29*(4), 645–671.

Larsen-Freeman, D. (1994). On the parallels between chaos theory and second language acquisition [Paper presentation]. Second Language Research Forum, McGill University, Montreal.

Larsen-Freeman, D. (1997). Chaos/complexity science and second language acquisition. *Applied Linguistics, 18*(2), 141–165. https://doi.org/10.1093/applin/18.2.141

Larsen-Freeman, D. (2006). The emergence of complexity, fluency and accuracy in the oral and written production of five Chinese learners of English. *Applied Linguistics, 27*, 590–619. https://doi.org/10.1093/applin/aml029

Larsen-Freeman, D. (2017). Complexity theory: The lessons continue. In L. Ortega & Z. Han (Eds.), *Complexity theory and language development* (pp. 11–50). John Benjamins.

Larsen-Freeman, D. (2018). Resonances: Second language development and language planning and policy from a complexity theory perspective. In M. Siiner, F. M. Hult, & T. Kupisch (Eds.), *Language policy and language acquisition planning* (pp. 203–217). Springer.

Larsen-Freeman, D., & Cameron, L. (2008). *Complex systems and applied linguistics*. Oxford University Press.

Lau, N.-.C., & Ploshay, J. J. (2013). Model projections of the changes in atmospheric circulation and surface climate over North America, the North Atlantic, and Europe in the twenty-first century. *J. Clim. 26*, 9603–9620. https://doi.org/10.1175/JCLID-13-00151.1

Lesonen, S., Steinkrauss, R., Suni, M., & Verspoor, M. (2021). Dynamic usage-based principles in the development of L2 Finnish evaluative constructions. *Applied Linguistics, 42*(3), 442–472.

Lewars, E. G. (2011). *Computational chemistry: Introduction to the theory and applications of molecular and quantum mechanics*. Springer.

Li, J., & Schmitt, N. (2009). The acquisition of lexical phrases in academic writing: A longitudinal case study. *Journal of Second Language Writing, 18*(2), 85–102.

Linck, J. A., Osthus, P., Koeth, J. T., & Bunting, M. F. (2014). Working memory and second language comprehension and production: A meta-analysis. *Psychonomic Bulletin & Review, 21*(4), 861–883.

Lowie, W. M., Caspi, T., Van Geert, P., & Steenbeek, H. (2011). Modeling development and change. In M. H. Verspoor, K. De Bot, & W. Lowie (Eds.), *A dynamic approach to second language development: Methods and techniques* (pp. 22–122). Benjamins.

Lowie, W. M., Van Dijk, M., Chan, H. P., & Verspoor, M. H. (2017). Finding the key to successful L2 learning in groups and individuals. *Journal of Language Teaching and Learning, 7,* 127–148. https://doi.org/10.14746/ssllt.2017.7.1.7

Lowie, W. M., & Verspoor, M. H. (2019). Individual differences and the ergodicity problem. *Language Learning, 69*, 184–206. https://doi:10.1111/lang.12324

Lowie, W. M., Verspoor, M. H., & de Bot, K. (2010). A dynamic view of second language development across the lifespan. In K. de Bot & R. W. Schrauf (Eds.), *Language development over the lifespan* (pp. 125–146). Routledge.

Mellow, J. D. (2008). The emergence of complex syntax: A longitudinal case study of the ESL development of dependency resolution. *Lingua, 118*(4), 499–521.

Menke, M. R., & Strawbridge, T. (2019). The writing of Spanish majors: A longitudinal analysis of syntactic complexity. *Journal of Second Language Writing, 46*, 1–15. https://doi.org/10.1016/j.jslw.2019.100665

Mercer, S. (2011). Language learner self-concept: Complexity, continuity and change. *System, 39*(3), 335–346.

Mufwene, S. S., Coupé, C., & Pellegrino, F. (Eds.) (2017). *Complexity in language: Developmental and evolutionary perspectives.* Cambridge University Press.

Munro, M. J., & Derwing, T. M. (2008). Segmental acquisition in adult ESL learners: A longitudinal study of vowel production. *Language Learning, 58*(3), 479–502.

Nitta, R., & Baba, K. (2015). Self-regulation in the evolution of the ideal L2 self: A complex dynamic systems approach to the L2 motivational self-system. In Z. Dörnyei, P. D. MacIntyre, & A. Henry (Eds.), *Motivational dynamics in language learning* (pp. 374–404). Multilingual Matters.

Nitta, R., & Baba, K. (2018). Understanding benefits of repetition from a complex dynamic systems perspective. In M. Bygate (Ed.), *Learning language through task repetition* (pp. 279–309). John Benjamins Publishing Company.

Piniel, K., & Csizér, K. (2015). Changes in motivation, anxiety and self-efficacy during the course of an academic writing seminar. *Motivational dynamics in language learning, 81*, 164–194. https://doi.org/10.21832/9781783092574-015

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., et al. (2021). The prisma 2020 statement: An updated guideline for reporting systematic reviews. BMJ 372:n71. https://doi.org/10.31222/osf.io/v7gm2

Pfenninger, S. E. (2022). Emergent bilinguals in a digital world: A dynamic analysis of long-term L2 development in (pre)primary school children. *International Review of Applied Linguistics in Language Teaching, 60*(1), 41–66.

Polat, B., & Kim, Y. (2014). Dynamics of complexity and accuracy: A longitudinal case study of advanced untutored development. *Applied Linguistics, 35*(2), 184–207.

Ramos, S., García, Y. F., Antón, E., Casaponsa, A., & Duñabeitia, J. A. (2017). Does learning a language in the elderly enhance switching ability?. *Journal of Neurolinguistics, 43*, 39–48.

Rokoszewska, K. J. (2020). Intra-individual Variability in the Emergence of Lexical Complexity in Speaking English at Secondary School. *Theory and Practice of Second Language Acquisition, 6*(1), 107–142.

Rokoszewska, K. (2022). The dynamics of monthly growth rates in the emergence of complexity, accuracy, and fluency in L2 English writing at secondary school–a learner corpus analysis. *System, 106*, 102775. https://doi.org/10.1016/j.system.2022.102775

Rosmawati, R. (2014). Dynamic development of complexity and accuracy: a case study in second language academic writing. *Australian Review of Applied Linguistics, 37*(2), 75–100. https://doi.org/10.1075/aral.37.2.01ros

Routarinne, S., & Ahlholm, M. (2021). Developing requests in multilingual classroom interaction: A case of second language development in middle childhood. *Applied Linguistics, 42*(4), 765–790. https://doi.org/10.1093/applin/amaa048

Sauer, L., & Ellis, R. (2019). The social lives of adolescent study abroad learners and their L2 development. *The Modern Language Journal, 103*(4), 739–762. https://doi.org/10.1111/modl.12589

Schlüter, M., Baeza, A., Dressler, G., Frank, K., Groeneveld, J., Jager, W., Janssen, M. A., McAllister, R. R. J., Müller, B., Orach, K., Schwarz, N., Wijermans, N. (2017). A framework for mapping and comparing behavioural theories in models of socialecological systems. *Ecol. Econ. 131*, 21–35.

Serafini, E. J. (2017). Exploring the dynamic long-term interaction between cognitive and psychosocial resources in adult second language development at varying proficiency. *The Modern Language Journal, 101*(2), 369–390.

Shanker, S. G., & King, B. J. (2002). The emergence of a new paradigm in ape language research. *Behavioral and Brain sciences, 25*(5), 605–620.

Skiba, R., & Dittmar, N. (1992). Pragmatic, semantic, and syntactic constraints and grammaticalization: A longitudinal perspective. *Studies in Second Language Acquisition, 14*(3), 323–349.

Spoelman, M., & Verspoor, M. (2010). Dynamic patterns in development of accuracy and complexity: A longitudinal case study in the acquisition of Finnish. *Applied Linguistics, 31*, 532–553. https://doi.org/10.1093/applin/amq001

Serrano, R., & Howard, E. (2007). Second language writing development in English and in Spanish in a two-way immersion programme. *International Journal of Bilingual Education and Bilingualism, 10*(2), 152–170.

Van Dijk, M., Verspoor, M. H., & Lowie, W. M. (2011). Variability analyses in language development. In *A dynamic approach to second language development: Methods and techniques* (pp. 55–84). John Benjamins Publishers.

Van Geert, P., & van Dijk, M. (2002). Focus on variability: New tools to study intra-individual variability in developmental data. *Infant Behavior & Development, 25*, 340–374.

Verspoor, M., Lowie, W., Chan, H., & Vahtrick, L. (2017). Linguistic complexity in second language development: Variability and variation at advanced stages. Recherches en didactique des langues et des culture. *Les Cahiers de l'Acedle, 14*(1), 1–27. https://doi.org/10.4000/rdlc.1450

Verspoor, M., Lowie, W., & Wieling, M. (2021). L2 developmental measures from a dynamic perspective. In B. Le Bruyn & M. Paquot (Eds.), *Learner corpus research meets second language acquisition* (pp. 172–190). Cambridge University Press.

Verspoor, M., Lowie, W., & Van Dijk, M. (2008). Variability in second language development from a dynamic systems perspective. *Modern Language Journal, 92*, 214–231. https://doi: 10.1111/j.1540-4781.2008.00715.x

Verspoor, M. H., de Bot, K., & Lowie, W. (Eds.) (2011). *A dynamic approach to second language development: Methods and techniques.* John Benjamins.

Verspoor, M., & van Dijk, M. (2011). Visualizing interaction between variables. In M. H. Verspoor, K. de Bot, & W. Lowie (Eds.), *A Dynamic Approach to Second Language Development* (pp. 85–98). John Benjamins Publishing Company.

Verspoor, M. & van Dijk, M. (2012). Variability in a dynamic systems theory approach to second language acquisition. In C. Chapel (Ed.), *The Wiley- Blackwell Encyclopedia of Applied Linguistics*. Blackwell Publishing.

Vyatkina, N. (2012). The development of second language writing complexity in groups and individuals: A longitudinal learner corpus study. *The Modern Language Journal, 96*(4), 576-598. https://doi.org/10.1111/j.1540-4781.2012.01401.x

Vyatkina, N., Hirschmann, H., & Golcher, F. (2015). Syntactic modification at early stages of L2 German writing development: A longitudinal learner corpus study. *Journal of Second Language Writing, 29*, 28–50.

Wind, A. M. (2021). Nonlinearity and inter-and intra-individual variability in the extent of engagement in self-reflection and its role in second language writing: A multiple-case study. *System, 103*, 102672. https://doi.org/10.1016/j.system.2021.102672

Wong, P. C., Ou, J., Pang, C. W., Zhang, L., Tse, C. S., Lam, L. C., & Antoniou, M. (2019). Language training leads to global cognitive improvement in older adults: A preliminary study. *Journal of Speech, Language, and Hearing Research, 62*(7), 2411–2424.

Yu, H., & Lowie, W. (2020). Dynamic paths of complexity and accuracy in second language speech: A longitudinal case study of Chinese learners. *Applied Linguistics, 41*(6), 855–877. https://doi.org/10.1093/applin/amz040

Zhang, Y. (2004). Processing constraints, categorial analysis, and the second language acquisition of the Chinese adjective suffix-de (ADJ). *Language Learning, 54*(3), 437–468.

Zhang, J., & Lu, X. (2013). Variability in Chinese as a foreign language learners' development of the Chinese numeral classifier system. *The Modern Language Journal, 97*(S1), 46–60.

Zhang, S., Zhang, H., & Zhang, C. (2022). A Dynamic Systems study on complexity, accuracy, and fluency in English writing development by Chinese university students. *Frontiers in Psychology, 13*, 787710.

Zheng, Y. (2016). The complex, dynamic development of L2 lexical use: A longitudinal study on Chinese learners of English. *System, 56*, 40–53.

Soheil Behdarvandirad

## Systematische Übersicht des Zweitspracherwerbs aus der Perspektive der Theorie komplexer dynamischer Systeme

Zusammenfassung

Aus der Sicht der Theorie komplexer dynamischer Systeme (CDST) weist die Zweitsprachentwicklung unvorhersehbare und nicht-lineare Muster auf, die von Lerner zu Lerner variieren können. Um diese dynamische Entwicklung nachzuvollziehen, sind Längsschnittstudien mit einer entsprechenden Anzahl von Datenpunkten erforderlich. Die

vorliegende systematische Literaturübersicht versucht, einen Überblick über die bisher durchgeführten Längsschnittstudien zu geben, welche die Entwicklung der zweitsprachlichen Teilsysteme im Hinblick auf die CDST-Theorie verfolgt haben. Ausgehend von Veröffentlichungen aus dem Jahre 1884 werden im Rahmen der systematischen Suchstrategie insgesamt 45 Artikel einer Analyse unterzogen, um den aktuellen Stand der Forschung darzulegen. Die untersuchten Studien sprechen eindeutig für die Umsetzung der CDST-Prinzipien in der Zweitsprachentwicklung. Es wird eine Synthese der Ergebnisse von Arbeiten vorgestellt und abschließend eine Vielzahl von Vorschlägen für weitere Forschung gegeben, die zukünftigen Studien helfen können, die bestehenden Lücken in der Literatur zu klären.

*Schlüsselwörter:* Zweitsprachentwicklung, Zweitspracherwerb, CDST, systematische Übersicht