

# Dynamic Development of Complexity, Accuracy and Fluency in Multilingual Learners' L1, L2 and L3 Writing

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**Abstract**—From a dynamic systems theory perspective, this study investigated the development of complexity, accuracy and fluency (CAF) in five undergraduate multilingual learners' L1 (Chinese), L2 (English) and L3 (French) writing throughout an academic year. Via detailed analysis of the quantitative data, this study aims to longitudinally depict the dynamic and interactive development of CAF in multilingual learners' writing. Results show that the developmental patterns of CAF in multilingual learners' (especially each individual learner's) L1, L2 and L3 writing were characterized by non-linearity, recurrent and elusive increase and backsliding, emergent and constant changes, chaotic iteration, etc. Results also demonstrate that CAF components were integratively and interactively correlated with each other in multilingual learners' writing over time. The findings hold some implications for theories and methodologies of multilingual acquisition/development studies.

**Index Terms**—dynamic systems theory, complexity, accuracy, fluency, multilingual development

## I. INTRODUCTION

Within the theoretical framework of dynamic systems theory (DST), this study is implemented to observe the development of complexity, accuracy and fluency (CAF) in five multilingual learners' L1, L2 and L3 writing throughout a 10-month period. Via in-depth analysis of the quantitative data, this study seeks to portray the dynamic and interactive developmental patterns of CAF in multilingual learners' writing over time. In what follows we present a literature overview of the relevant studies concerning DST and its application to language acquisition/development so as to theoretically and methodologically conceptualize our present research.

### A. *The DST Approach to First and Second Language Acquisition (SLA)*

DST, which grows directly from mathematics and physics, originally serves to analyze and model the nonlinear development and change of complex systems (de Bot & Larsen-Freeman, 2011; Larsen-Freeman, 2013; Thelen & Smith, 2006). Simply speaking, DST is not a specific theory, but rather a very general approach to depicting and explaining change (van Geert, 2008). With the gradual and extensive acknowledgement of the cardinal principles within DST, scientists have increasingly introduced this theory to the study of human cognition and behavior development in the last two decades. For instance, Thelen and Smith (1994) and van Geert (1994), drawing upon the notion of development as a self-organizing system, were among the first to apply DST to developmental psychology. A great many groundbreaking positions are proposed by these psychologists, a crucial one being that, the "acquisition of mental life is continuous with all biological growth of form and function" (Thelen & Smith, 1994, p. XIII.) This is also applicable to language development, "which is not seen as something special in the cognitive system, but as a part of the larger system that develops in a similar fashion" (de Bot, 2008, p. 169). In other words, language development can be deemed as one aspect of general human development (de Bot, 2008).

The pioneering studies concerning DST carried out by developmental psychologists have inspired researchers of applied linguistics, which engenders a number of relevant books and articles on language and language learning from a DST perspective (see e.g., de Bot & Larsen-Freeman, 2011; de Bot, Lowie, & Verspoor, 2007; Larsen-Freeman, 1997, 2011, 2012; Verspoor, de Bot, & Lowie, 2011). As demonstrated by these publications, language embodies all the characteristics of dynamic systems, which include, e.g., sensitive dependence on initial conditions, self-adaption and self-organization, complete interconnectedness, nonlinearity and chaos in development, dependence on internal (cognitive) and external (social) resources, emergent properties (for detailed elaboration on characteristics of DST, see Larsen-Freeman, 1997, 2013; de Bot & Larsen-Freeman, 2011). Then it follows naturally that many of the phenomena of interest to language acquisition, and language development in particular, can be regarded as dynamic systems as well (Larsen-Freeman, 1997; Spoelman & Verspoor, 2010), and this is true for both L1 and L2 development (Larsen-Freeman, 2006). Here we may present two examples so as to account for the dynamics of language acquisition.

First, given the assumption that language acquisition is a dynamic and nonlinear process, there would be waxing and waning of patterns (i.e., much unpredictable variability) emerging from language development instead of discrete stages in which learners' performance is invariant (Larsen-Freeman, 2006). Second, the inherent feature of dependence on internal and external recourses indicates that language is both a cognitive and a social phenomenon and that cognitive processing and social situation of language use can not be treated separately. This holistic notion of language properties elucidates that such factors as memory capacity, motivation, learners' identity, environment in which learning takes place may simultaneously and interactively exert profound effects on language acquisition (de Bot & Larsen-Freeman, 2011; Larsen-Freeman, 2006). All in all, the conceptualizations of language and language acquisition from a DST perspective diverge fundamentally from the mainstream or traditional theories working with static or linear presuppositions (e.g., information processing approach) that have dominated cognitive sciences and applied linguistics in the past several decades (de Bot, Lowie, & Verspoor, 2007), and such an innovative theoretical and methodological framework may provide refreshing insights into our understanding and studying of language acquisition.

### B. *The DST Approach to Third Language Acquisition (TLA) or Multilingualism*

*From SLA to TLA or multilingualism.* In recent years, studies dedicated to TLA or multilingualism have rapidly thrived (see e.g., Aronin & Hufeisen, 2009; Cenoz & Jessner, 2000; Cenoz, 2013a; De Angelis, 2007; Herdina & Jessner, 2002), given that the population learning more than two languages is expanding sharply, and that important discrepancies between SLA and TLA have increasingly been recognized and uncovered by inquirers (see Cenoz, 2013a, 2013b; De Angelis, 2007). Admittedly, TLA shares many of the common grounds with SLA (e.g., they are both processes of acquiring a non-native language), but there are also significant distinctions between them, which have very often been ignored by SLA research (Cenoz, 2013a). The primary difference lies in the fact that third or additional language learners already have two or over two languages in their prior linguistic repertoire, which can influence the language learning processes in various ways (Cenoz, 2013a; De Angelis, 2007). Hence, it is obvious that learners of third or additional languages may take advantage of more linguistic resources (L1, L2 and other prior languages acquired) during the production and acquisition processes which SLA learners or bilinguals definitely do not have at their disposal (Cenoz, 2013a, 2013b; De Angelis, 2007). In reality, diverse elements such as learners' age and motivation, order of acquisition, instructional methods may all constitute distinguishing factors that may differentiate SLA from TLA (Cenoz, 2013a). Hufeisen (2004) accordingly proposed a position that salient qualitative differences could be discerned between SLA and TLA rather than between TLA and acquisition of more than three languages, i.e., acquisition of L4, L5, L6...Lx. All these facts raised above may therefore justify why TLA or multilingualism can elicit increasing attention in language acquisition studies, and TLA and multilingualism can be a promising and unique research terrain in applied linguistics.

*Multilingualism from the perspective of DST.* As manifested in the foregoing illustrations, language development is a complex and dynamic process. Concurrently with an increase in the quantity of languages involved in multilingual development, "the dynamics, that is, the changes and complexity of language learning, become even more evident" (Jessner, 2008, p. 270). From such a dynamic perspective, multilingual acquisition (especially multilingual development), a far more complicated process than SLA, is assumed to encompass several noticeable properties, e.g., constant and complex change over time, nonlinearity and reversibility in development, and interdependence of language systems (see Herdina & Jessner, 2002; Jessner, 2008). As stated in Jessner (2008), multilingual development undergoes constant and complex change in that all languages of multilinguals dynamically and continuously evolve and vary among and within individuals, and that even if certain parts of the multilingual system are to some degree fossilized, they may still more or less affect rest of the multilingual systems; in addition, nonlinearity and reversibility in the developmental processes points to the fact that the acquisition of an additional language (e.g., L3) can counteract L1 or L2 maintenance or growth, leading to more frequent occurrence of language attrition or loss in multilinguals as compared with bilinguals; last but not the least, interdependence of language systems signifies that all individual language systems within a multilingual system, intimately and intricately interconnected, need to be taken as a unified whole rather than as isolated and autonomous systems.

Over the last two years, there emerges a new noteworthy approach in multilingual research, namely *focus on multilingualism* (see, e.g., Cenoz, 2013; Cenoz & Gorter, 2011), of which the essential norms are entirely deviant from the monolingual models that permeate the field of SLA research but seem inadequate in exploring multilingualism. Actually the basic frames of *focus on multilingualism* are perfectly in line with DST. Through employing a holistic view of multilingualism, this approach aims to observe the intense connectivity and complex dynamic interplay of all the languages within a multilingual's repertoire, and the way in which these languages support or compete with each other during the developmental processes. Such a notion definitely corresponds to the major properties of multilingual systems as assumed by DST. In this sense, while DST is expected to lay a solid theoretical foundation for ongoing and upcoming multilingual studies, *focus on multilingualism* may be considered as methodological specialization and actualization of DST.

### C. *Rationale for the Present Study*

Although the field of applied linguistics has witnessed an increasing number of language acquisition research within the DST framework, most of these investigations exclusively concentrated on native speakers' L1 or second language

learners' L2 development. Little has been done to observe multilinguals' L3 acquisition/development, and studies that holistically take into account learners' L1, L2 and L3 development are much scarcer (see Kobayashi & Rinnert, 2013). In light of the qualitative differences between SLA and TLA as well as the complex and dynamic nature of multilingual systems as presupposed by DST, the present study is intended to inquire into multilinguals' L1, L2 and L3 writings simultaneously via analysis of some developmental metrics, i.e., CAF, which may sketch a relatively complete picture of whether and how learners' multiple languages dynamically and interactively develop as represented in their writing.

Moreover, while some position papers have hypothetically proposed the dynamic model of multilingualism (e.g., Model of Multilingualism raised by Herdinan & Jessner 2002; Jessner, 2008) and certain approach to studying multilingualism (e.g., *focus on multilingualism* as mentioned above) which both theoretically conceptualize multilingual acquisition and methodologically blaze a novel trail for multilingual research, formal empirical studies that investigate the dynamism of multilingual acquisition/development are still scant. In other words, there is palpable imbalance between ample theories and deficient empirical evidence in the study of dynamic multilingual acquisition/development. Therefore, the present exploratory study is performed to fill this empirical gap in multilingual research.

In addition to the aforementioned points, the current research attaches utmost significance to multilingual learners' individual discrepancies, which is different from many foregoing studies of second/third language development (and studies of second/third language writing development in particular) that base their conclusions on mean analysis of group data (e.g., Biber & Gray, 2011; Sasaki, 2004, 2007). One might doubt that findings of individual details could not be generalized. However, the issue of *generalization* itself is somewhat problematic. For one thing, generalization in traditional statistics refers to the applicability of findings on the sample level to the population that the sample is assumed to represent, but drawing a representative sample from a population is very difficult and hardly any research in applied linguistics would rightly claim to be generalizable beyond the sample it is based on (Verspoor, de Bot & Lowie, 2011). For another, generalizations about learning, i.e., results yielded from mean analysis of group learners, may tremendously disguise individual variations, and are "elusive and not likely to hold regardless of individual differences" (Larsen-Freeman, 2006, p. 594). In fact, "individual developmental paths, each with all its variation, maybe quite different from one another, even though in a GRAND SWEEP view these developmental paths are quite similar." (de Bot, Lowie, & Verspoor, 2007, p. 14). Individual variability is, in essence, not *error* or *noise* in second language development, and it can help reveal intriguing developmental mechanisms (Verspoor, Lowie, & van Dijk, 2008). Selinker (1972, p. 213) has already asserted that "a theory of second language learning that does not provide a central place for individual differences among learners cannot be considered acceptable". Therefore, aside from group averages, laying particular stress on individual's developmental aspects corresponds not only to the necessity of describing and explaining the development and use of multiple languages in individuals (de Bot & Larsen-Freeman, 2011), but also to the call for more studies of individual multilingual acquisition than group studies within the theoretical parameters of DST (see Jessner, 2008).

Last but not the least, this study, adopting CAF as the instruments to longitudinally measure multilingual development in writing, is aligned with the advocacy of integrating CAF studies with more dynamic descriptions as suggested by Norris and Ortega (2009). Irrespective of a few controversies over their roles in language acquisition, the three indices have long figured as important criteria to assess learners' written or oral productions or even as effective indicators of learners' L1 or L2/foreign languages proficiency underlying their performance (see Housen & Kuiken, 2009; Li, 2006). In recent years, Norris and Ortega (2009) argued that CAF, inconstant and unpredictable over time, was multifaceted, and its dynamics can be best understood integratively and across the full developmental trajectory (Spoelman & Verspoor, 2010). Likewise, Larsen-Freeman (2006) contended that capturing the ongoing emergence of CAF was one of the challenges facing SLA researchers. In the meantime, some perpetual puzzles pertinent to CAF, e.g., the interaction and interdependence of CAF components within learners' single language development (see Housen & Kuiken, 2009) or that of CAF constituents across learners' different languages, have yet to be resolved. Given all these observations raised above, the present inquiry is hence an attempt to obtain a detailed vision of the developmental trajectories concerning CAF in multilinguals' L1, L2 and L3 writing.

## II. METHODOLOGY

### A. Participants

Five third-year undergraduate Chinese students (one male and four females) from a university in China, ranging in age from 20 to 21 years, volunteered to participate in the study in exchange for payment, and all of them were actually quite interested in such a research. Here these students will be referred to as F, L, S, W, and Z to preserve their anonymity. They were enrolled in a 4-year undergraduate French Language and Literature Program, in which they took various French skill courses (e.g., reading, listening, speaking, writing and translation) of 15-18 hours per week. All Chinese French majors are obliged to finish this program to obtain a Degree of Bachelor of Art. In the French writing class, students would learn various models of writing, e.g., narration, exposition and argumentation, and they would receive instructions on a number of elements in writing, e.g., diction of vocabularies and syntax, employment of rhetoric strategies and cohesion to govern the textual construct.

Before entering college, these participants had no knowledge of French language and had, on average, received 9 years of formal compulsory EFL education and demonstrated English as well as other academic skills as part of the

university entrance process. Their English scores on the Chinese college entrance exam were above the 72 percentile nationally for Chinese college applicants. In college, they continued to take the 2-hour per week English language courses (e.g., reading, writing and speaking) which last for three years and are compulsory. Moreover, no one has ever experienced overseas education or has learned any languages other than mandarin Chinese, English and French. In a word, these multilingual learners have thus mandarin Chinese as their L1, English as L2 and French as L3 in terms of the chronological sequence of language acquisition. As for their foreign language proficiency, all of them have passed CET-6 (College English Test Band 6, the official national English proficiency test targeted at college students through the examination of the basic language skills, i.e., listening, reading, writing and translation) and TFS-4 (Test national du français enseigné à titre de spécialité niveau IV, the official national French proficiency test targeted at French majors through the examination of the basic language skills like speaking, listening, reading, writing, etc.), and all obtained moderate scores on these tests (from 66% to 73% of the full scores of the tests). Hence, both their L2 and L3 proficiency can be regarded as intermediate according to the ranking benchmark of foreign language proficiency as set forth by the College Foreign Language Teaching and Examination Committee of Chinese Ministry of Education.

### B. Data Collection

The participants performed the untimed writing tasks once every two months throughout an academic year (September 2011-June 2012), and in other words, the data were collected 5 times (October 2011, December 2011, February 2012, April 2012 and June 2012) over the 10-month period. Each time they were first asked to compose a narrative essay in Chinese (L1 writing). After a one-week interval they wrote in English (L2 writing), and finally they composed in French (L3 writing) a week after the L2 writing task. Neither dictionary nor reference books were allowed. The minimal required length for L1 writing was 500 *zi*<sup>1</sup>, and that for L2/L3 writing was 200 words. In addition, the topics across L1, L2 and L3 writing were the same. Altogether the participants carried out the narrative writing tasks of 5 specific topics (e.g., an event that makes me happy, an event that makes me angry, an unforgettable lesson in my life) respectively for each time of data collection. These topics, albeit seemingly different, unanimously fall under the umbrella of the genre of personal experience narratives, i.e., writers' monologues about very impressive personal events or experiences. Such kind of uniformity in genre, no doubt, makes the comparative inquiry of the longitudinal written data of distinct topics feasible.

### C. Data Analysis

All the writing samples were analyzed in terms of fluency (mean number of words per t-unit, a t-unit being a minimal terminal unit or an independent clause with whatever related subordinate clauses and non-clausal structures attached to or embedded in it), accuracy (the proportion of error-free t-units to total number of t-units), lexical complexity (Guiraud's index: word types divided by the square root of the word tokens) and grammatical complexity (mean number of clauses per t-unit), as these indices have been documented to be most reliable measures of language development in writing and speaking (see, e.g., Wolfe-Quintero, Inagaki, & Kim, 1998; Housen, Kuiken, & Vedder, 2012).

A significant point that merits attention is that we did not directly draw upon the definitions of clause and t-unit for English and other European languages (see, e.g., Hunt, 1965) in the analysis of L1 Chinese writings. Taking into account the syntactic differences between Chinese and Indo-European languages, we categorized these two concepts in Chinese writing by virtue of the operational definitions respectively proposed by Chu (1998) and Jiang (2013). Therefore, in our study a Chinese clause is a linguistic unit "minimally consisting of a predicate of various forms" (Chu, 1998, p. 354), and a Chinese t-unit is "a single main clause that contains one independent predicate plus whatever other subordinate clauses or non-clauses are attached to, or embedded within, that one main clause" (Jiang, 2013, p. 5). In addition, when demarcating type and token in Chinese writing, we calculated Chinese *word* (also named *syntactic word* by Chao, 1968), i.e., a minimal linguistic form that has meaning, can occur independently in speaking and writing (Fu, 1985; Zhu, 1982), and has translation equivalent in other languages (Chao, 1968), rather than Chinese *zi*. This procedure was achieved with the aid of ICTCLAS2013 (Zhang, 2013), an authoritative computer software program for identification and segmentation of Chinese words in written texts.

We independently coded all the written samples. Our interrater reliability was checked and reached 0.92. Then we examined each other's coding, discussed discrepancies, and attained 100% agreement. The quantitative data were finally plotted in Microsoft Excel charts for the sake of visualizing the complex and dynamic development of CAF in multilinguals' writing.

### D. Expected Findings

Very much like the research conducted by Larsen-Freeman (2006), this study, being exploratory in nature, does not aim to test any hypothesis, but expect to obtain, among other things, the following findings:

1. At the group level, multilingual learners may show stable and level patterns in their L1 writing development, with neither significant growth nor decrease, while they may demonstrate general linear downward trends in their L2 and

<sup>1</sup> The minimal free form (or the basic unit) in English and other Indo-European languages is *word* (see Bloomfield, 1933), whereas that in Chinese is *zi* (Chao, 1968; Zhu, 1982; Pan, 2002). There are no exact matches between Chinese *zi* and *word* in Indo-European languages, as the two units, despite some conceptual overlaps, have fundamental distinctions. In linguistic analysis, the approximate Chinese equivalent of *word* in English may be called *syntactic word* (see Chao, 1968), which can be a unigram (a single *zi*), bi/trigram (consisting of two or three *zi*), or even a four-gram.

overt smooth upward trajectories in L3 writing development in terms of CAF analyzed.

2. Non-linear/dynamic developmental processes and a great deal of variation (e.g., waxing and waning of language patterns with recurrent progression and regression, emergent and constant changes, iterative and chaotic development, no clear cut-off stages in development) may be identified in interindividual's (between individuals) L1, L2 and L3 writing via CAF analyzed.

3. Non-linear/dynamic developmental processes and a great deal of variation (e.g., waxing and waning of language patterns with recurrent progression and regression, emergent and constant changes, iterative and chaotic development, no clear cut-off stages in development) may be identified in intraindividual's (within one individual) L1, L2 and L3 writing via CAF analyzed.

4. CAF components do not develop in isolation, given that they may either support or compete with each other. The interaction and interdependence of CAF can be discerned within individual multilingual learner's writing of a single language and across individual's writings of different languages.

### III. RESULTS

#### A. Group Averages over Time

Fig. 1A-1C indicate that group averages of the four measurements in L1, L2 and L3 writing underwent almost entirely different developmental paths. Over the 10-month period, L1 fluency first increased sharply (from 13.94 in October to 15.49 in December), and then decreased substantially (from 15.49 in December to 13.08 in April) to the bottom point, and finally it grew again (from 13.08 in April to 15.31 in June). In contrast, L1 lexical complexity developed in a reversed fashion as compared with fluency: it declined from October to December (12.78→11.99), and between February and April it went through dramatic growths (11.99→12.82) and drops (12.82→11.74), and after April it slightly increased. Meanwhile, L1 accuracy went through a U-shaped development in which the peak (0.958 in October) fell rapidly to the valley (0.894 in February) and grew remarkably from February to June (0.894→0.94). Last, grammatical complexity measures revealed an overall declining tendency, with the exception of a minor increase in December.

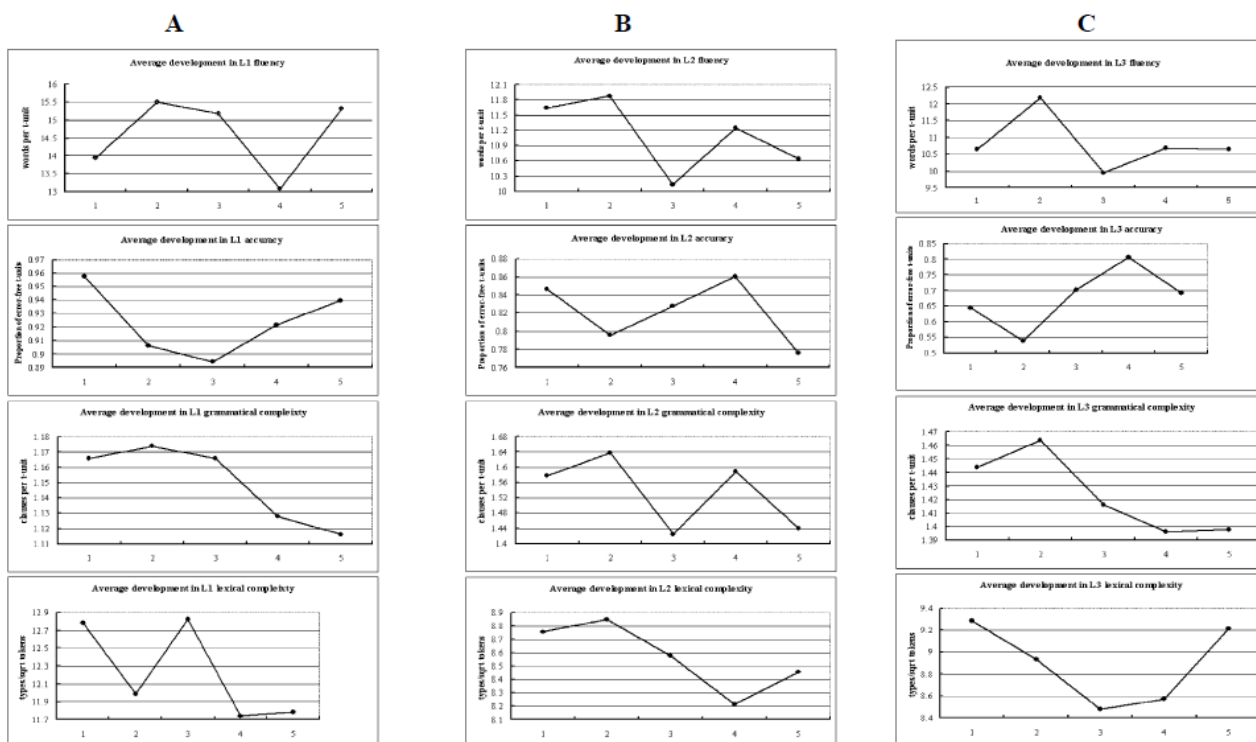


Figure 1. A: Group average development of CAF in L1 writing; B: Group average development of CAF in L2 writing; C: Group average development of CAF in L3 writing

As for L2 writing, although the last values in June of all the four indices were unanimously lower than the initial ones in October, their twisted developmental trajectories, teemed with waxes and wanes from time to time, were not demonstrative of linear and smooth downward trends. With respect to L3 writing, the fluency metrics underwent salient ups (10.64→12.18) and downs (12.18→9.94) from October to February, and after February it again increased slightly until June (9.94→10.65). L3 accuracy development, irrespective of its global upward tendency, actually went through salient regress (from 0.645 in October to 0.539 in February; from 0.807 in April to 0.692 in June) and substantial progress (from 0.539 in February to 0.807 in April) consecutively. In the meantime, grammatical complexity was

indicative of an overall declining path with the exception of slight growth in December, whereas lexical complexity exhibited a U-shaped curve (from 9.29 in October to 8.48 in February; from 8.48 in February to 9.22 in June).

Although group averages may provide some useful information for analyzing learner language development, they may nonetheless portray a process which can conceal a large body of variability (Larsen-Freeman, 2006), and has no validity for any individual (Sidman, 1960). Therefore, our study will focus primary endeavors on individual variations by disaggregating the group data.

*B. Interindividual Differences over Time*

In comparison with the group averages which seem to display relatively smoother curves, individuals showed a great deal of variability in all the four measures across L1, L2 and L3 writings (see Fig. 2A-2C). Actually none of the learners followed the group averaged trajectories. For their L2 and L3 writing, some of the variations were more pronounced and others relatively leveled off and less noticeable. But their performances, in the main, were in constant or even chaotic change over time, with recurrent growths and declines. Therefore, their L2 and L3 did not indicate regressive inconformity or progressive conformity to the target language norms, and individual developmental paths diverged significantly from each other. Meanwhile, it warrants further attention that even learners' L1 did not cease to change and were not supposedly fossilized, which demonstrates a number of individual differences.

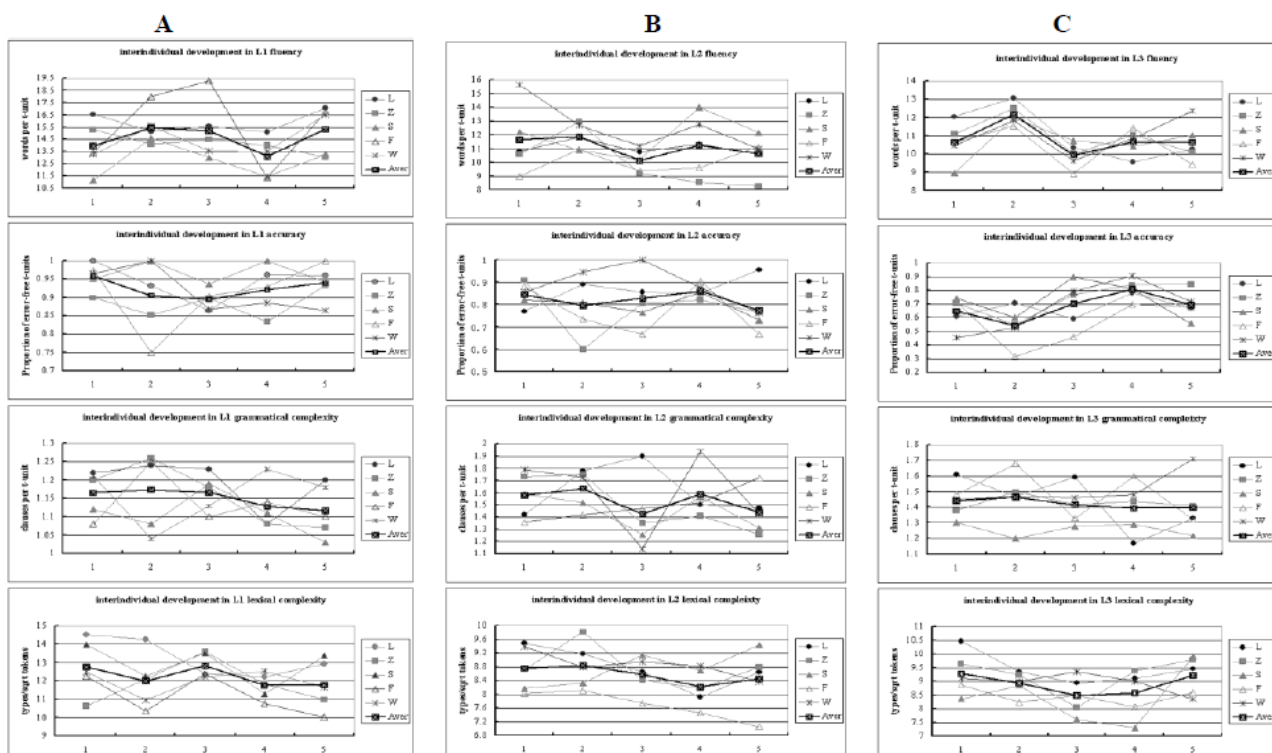


Figure 2. A: Interindividual development of CAF in L1 writing; B: Interindividual development of CAF in L2 writing; C: Interindividual development of CAF in L3 writing

*C. Intraindividual Variations over Time*

Intraindividual variations were examined in terms of two aspects. First, analyzing and comparing one single measurement across L1, L2 and L3 writing over time (e.g., fluency across L1, L2 and L3 writing). Second, observing all the four indices within writing of a single language (e.g., fluency, accuracy, grammatical complexity and lexical complexity in L1 writing) over time. For the second category of analysis, we normalized the performance measures by recalculating the data to values from 0-1 (see Verspoor, de Bot, & Lowie, 2011) so as to guarantee the comparability across the different constructs and represent all of them together within a single graph.

Due to limited space in the article, we can but selectively dwell on some intraindividual data to analyze the variations. We will start by probing one single measurement across L1, L2 and L3 writing and we may take the data from F as an example. As indicated in Fig. 3, L1, L2 and L3 fluency all ascended from October to December, and the growth for L1 was much more salient (from 13.42 to 18) than L2 (from 8.96 to 10.95) and L3 (from 10.67 to 11.53). From December to next June, L1 fluency dramatically declined (from 19.29 in February to 11.36 in April) and increased (from 11.36 in April to 16.7 in June). Over this period, though L2 and L3 fluency demonstrated fluctuations occasionally, their changes were obviously less pronounced in comparison with L1.

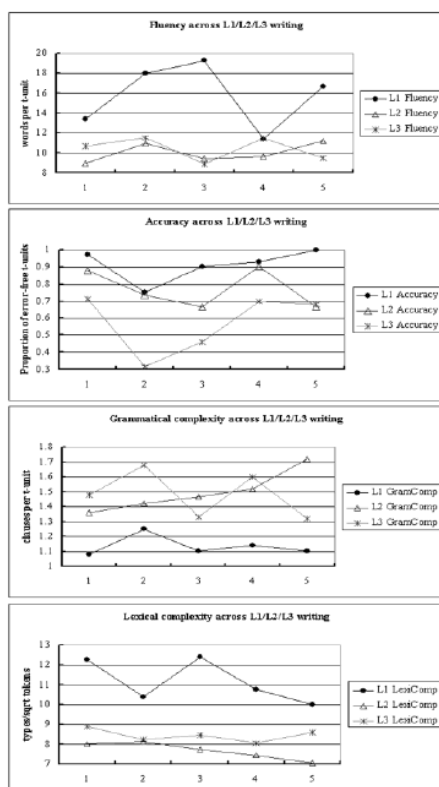


Figure 3. Intraindividual variation of a single index of CAF across F's L1/L2/L3 writing

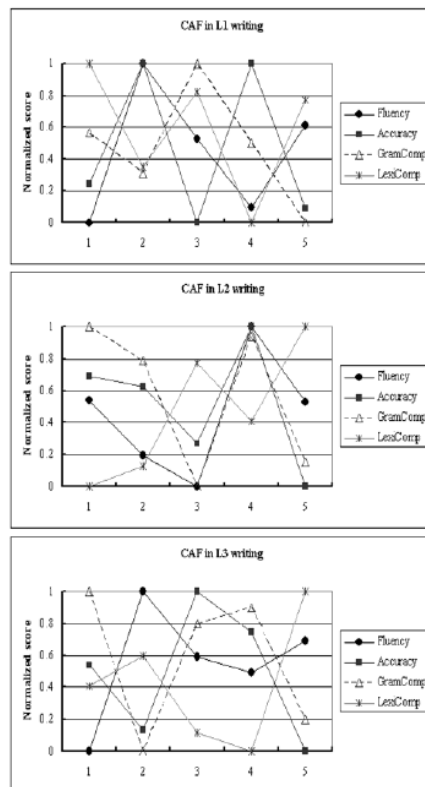


Figure 4. Intraindividual variation of CAF in S's writing of a single language over time

Concerning the accuracy index, initially it went down remarkably for L1 (from 0.97 to 0.75), L2 (from 0.88 to 0.74) and L3 (from 0.71 to 0.32). Then L1 accuracy continued to grow throughout the subsequent several months (L1 accuracy reached its peak, i.e., 1 in June). Meanwhile, L2 accuracy kept on decreasing and fell to the lowest point (0.67) in February, and after that it underwent conspicuous increase (from 0.67 in February to 0.9 in April) as well as decrease (from 0.9 in April to 0.67 in June). Over the period of December 2011 to June 2012, L3 accuracy witnessed a giant ascending leap (from 0.32 to 0.68).

With respect to grammatical complexity, it grew to its peak (1.25) in December in L1 writing, dropped remarkably from December to February (from 1.25 to 1.1), and for the rest six months it almost stabilized without any important changes. L2 complexity, on the other hand, was on the increase throughout the whole academic year, with a relatively more noticeable growth from April to June (1.52→1.72). Finally, L3 complexity embodied the largest variability as compared with L1 and L2 counterparts, because it alternatively went through salient increase (from October to December, 1.48→1.68; from February to April, 1.33→1.6) and decline (from December to February, 1.68→1.33; from April to June, 1.6→1.32) for two times.

As for lexical complexity, it initially exhibited a U-shaped curve in L1 writing (from October to December, 12.27→10.37; from December to February, 10.37→12.38), and then it went down constantly until June. In the meantime, L2 lexical complexity was in decline over the entire 10-month period, whereas the L3 equivalent underwent the U-shaped development twice successively in that time span (from October to December, 8.88→8.24, from December to February, 8.24→8.48; from February to April, 8.48→8.06, from April to June, 8.06→8.59).

For the sake of exploring the interactions of one measurement among F's L1, L2 and L3 writing (e.g., interactions between L1 fluency and L2 fluency; between L2 and L3 fluency; between L1 and L3 fluency) in the developmental processes, we further calculated the correlation coefficients. Table 1 and 2 demonstrates that certain degree of interplays of one single index among L1, L2 and L3 writing indeed existed. The positive correlations are indicative of a supportive relationship (i.e., variables develop in unison as they support each other), whereas the negative ones are suggestive of a competitive relationship (i.e., variables develop in alternating patterns as they compete with each other). There was, in particular, a significant positive correlation between L1 accuracy and L3 accuracy ( $r = .902, p < .05$ ), manifesting an intense supportive nexus between them.

TABLE 1  
THE INTERACTION OF A SINGLE MEASUREMENT OF CAF ACROSS F'S L1/L2/L3 WRITING (PEARSON'S R): PART ONE.

|             | L1 Fluency | L1 Accuracy | L1 GramComp | L1 LexiComp |
|-------------|------------|-------------|-------------|-------------|
| L2 Fluency  | .404       |             |             |             |
| L3 Fluency  | -.571      |             |             |             |
| L2 Accuracy |            | .135        |             |             |
| L3 Accuracy |            | .902*       |             |             |
| L2 GramComp |            |             | -.214       |             |
| L3 GramComp |            |             | .787        |             |
| L2 LexiComp |            |             |             | .485        |
| L3 LexiComp |            |             |             | ..482       |

\*: Correlation is significant at the .05 level.

TABLE 2  
THE INTERACTION OF A SINGLE MEASUREMENT OF CAF ACROSS F'S L1/L2/L3 WRITING (PEARSON'S R): PART TWO.

|             | L2 Fluency | L2 Accuracy | L2 GramComp | L2 LexiComp |
|-------------|------------|-------------|-------------|-------------|
| L3 Fluency  | .034       |             |             |             |
| L3 Accuracy |            | .514        |             |             |
| L3 GramComp |            |             | -.503       |             |
| L3 LexiComp |            |             |             | .101        |

Apart from examining one single measurement across L1, L2 and L3 writing, we also looked into CAF within writings of a single language. Here we may take the data from S as an example. As Fig. 4 shows, CAF within L1, L2 and L3 writing went through almost entirely distinct or even chaotic developmental trajectories. In L1 writing, fluency successively exhibited dramatic increase and decrease from October to April (from October to December, 0→1; from December to April, 1→0.096), and afterwards it grew remarkably again. In contrast, grammatical complexity changed in an opposite fashion: it initially underwent pronounced decrease and increase, and from February onwards it dropped conspicuously. Meanwhile, accuracy developed in a reversed U-shaped manner twice over the ten months period (from October to December: 0.243→1, from December to February: 1→0; from February to April: 0→1, from April to June, 1→0.088). Likewise, lexical complexity also consecutively showed reversed U-shaped developmental curves for two times throughout the whole academic year.

As for L2 writing, fluency fell to the lowest point from October to February (from 0.54 to 0), grew sharply to the peak from February to April (from 0 to 1), and finally decreased remarkably (from 1 to 0.529). Accuracy and grammatical complexity developed in fashions quite analogous to fluency, with the exception that the lowest point for accuracy was in June and that the peak for grammatical complexity was in December. In comparison with the above three indices, lexical complexity indicated a distinct trajectory: it increased conspicuously from October to February (from 0 to 0.772), declined greatly from February to April (from 0.772 to 0.409), and developed dramatically to its peak over the last two months (from 0.409 to 1).

With regard to L3 writing, fluency at first went up remarkably from October to December (0→1), and afterwards it went down until April (1→0.492). Then it increased again from April to June (0.492→0.696). Accuracy and grammatical complexity, on the other hand, seemed to resemble each other in the developmental trajectory as they both consecutively went through U-shaped curve and reversed U-shaped curve throughout the entire period, but they also diverged noticeably in their rate of change at different times of data collection. In the meantime, lexical complexity underwent tiny growth (from October to December, 0.406→0.598), salient decline (from December to April, 0.598→0) and dramatic increase (from April to June, 0→1) one after another over the academic year.

In order to discover the interactions of CAF within S's writing of a single language, we computed the correlation coefficients as well. Table 3-5 revealed that CAF actually correlated with each other to some extent within L1, L2 and L3 writing. The interplay was especially conspicuous between accuracy and lexical complexity ( $r = -.883, p < .05$ ) in L1 writing, between lexical complexity and grammatical complexity ( $r = -.88, p < .05$ ) in L2 writing, and between accuracy and lexical complexity ( $r = -.917, p < .05$ ) in L3 writing, which indicated a strong competitive relationship within each pair.

TABLE 3  
THE CORRELATION OF CAF IN L1 WRITING OF S (PEARSON'S R).

|                        | Fluency | Accuracy | Grammatical complexity |
|------------------------|---------|----------|------------------------|
| Fluency                |         |          |                        |
| Accuracy               | .133    |          |                        |
| Grammatical Complexity | -.291   | -.218    |                        |
| Lexical complexity     | -.088   | -.883*   | .165                   |

\*: Correlation is significant at the .05 level



TABLE 4  
THE CORRELATION OF CAF IN L2 WRITING OF S (PEARSON'S R).

|                        | Fluency | Accuracy | Grammatical complexity |
|------------------------|---------|----------|------------------------|
| Fluency                |         |          |                        |
| Accuracy               | .547    |          |                        |
| Grammatical Complexity | .574    | .876     |                        |
| Lexical complexity     | -.126   | -.756    | -.880*                 |

\*: Correlation is significant at the .05 level

TABLE 5  
THE CORRELATION OF CAF IN L3 WRITING OF S (PEARSON'S R).

|                        | Fluency | Accuracy | Grammatical complexity |
|------------------------|---------|----------|------------------------|
| Fluency                |         |          |                        |
| Accuracy               | -.416   |          |                        |
| Grammatical Complexity | -.850   | .811     |                        |
| Lexical complexity     | .316    | -.917*   | -.740                  |

\*: Correlation is significant at the .05 level

#### IV. DISCUSSION

All the expectations as laid out earlier are met, with the exception of the first one. Results yielded from data analysis indicate that at the group level multilingual learners failed to show stable and level patterns in their L1 writing development, and they demonstrated neither general linear downward trends in their L2 nor overt smooth upward trajectories in L3 writing development in terms of CAF analyzed. In reality, CAF in group learners' L1, L2 and L3 writings all developed in non-linear and dynamic fashions, with continuous and erratic changes (e.g., ups and downs) from time to time. This finding is somewhat contradictory to the Model of Multilingual Development (see Herdina & Jessner, 2002, p. 123; Jessner, 2008, p. 272) which posits that multilingual learners' L3 undergoes persistent increase, and the durative growth of L3 counteracts the maintenance of L2 (or even L1), leading to gradual attrition or loss of L2 (or even L1). These multilingual learners of our study had at least 15 hours of L3 classes and only 2 hours of L2 classes per week. Such a significant imbalance between L2 and L3 input (as well as output) would, as we suppose, bring out apparent backsliding of L2 and salient progress in L3 over time, because the multilingual systems, influenced by the instructional and learning context, are expected to adaptively vary. However, in actual case the group of learners did not go through such patterns of linear and smooth change, and instead they showed much more reversible and dynamic manners of development in both their L2 and L3. Moreover, the current discovery further corroborates the recently updated version of Critical Period Hypothesis (see Singleton, 2005; Singleton & Ryan, 2004) which proposes that there is no absolute stabilization or fossilization of L1 even for adults. Hence, the notion of fossilization or stabilization may not be quite applicable to L1 development of adult multilinguals, given that their L1 still varies saliently and elusively after the age of 20.

True, the grand group averages have preliminarily sketched the dynamics of multilingual development in terms of CAF, but the individual data further complicate the matter. Given that individual differences are not very often addressed in language acquisition research, investigators tend to assume that individual learners may undergo approximately the same developmental trajectories as the group pathways (Larsen-Freeman, 2006). However, our finding uncovers that none of the multilingual learners resembled the group averaged curves, since each individual's developmental processes as indexed by CAF in writings of L1, L2 and L3 are all replete with considerable variability and numerous dynamic patterns like emergent growth and backsliding, sustained and iterative alternations, etc. One might question if learners fail to make linear progress in L2 and L3 writing during a one-year period of learning and practice, as there should be requirements at the University for them to pass certain tests and exams. Nevertheless, the static or linear presuppositions for language acquisition are quite contradictory to the principles of DST. In reality, the changing of many possible internal factors (e.g., memory capacity, motivation) and external factors (e.g., time invested to support learning, pressure from teachers and parents) might lead to both growth and attrition in language development. Therefore, what we have presented in this paper are the virtual language developmental processes, in which continuities and discontinuities would emerge. As stated by Spoelman and Verspoor (2010, p. 533), "within-subject variability is functional and occurs continuously in any developing complex system". Through the seemingly messy interindividual and intraindividual trajectories described in the section of *Results*, we can perceive that the fundamental properties of dynamic systems, e.g., nonlinearity, emergence and everlasting changes, are intrinsic to individual multilingual development. The discoveries about individual variations, coupled with the group development elaborated above, corroborate that multilingual acquisition/development is a non-linear, dynamic and complex process which is much more intricate than SLA or bilingualism and may not be adequately and simply accounted for by theories of SLA. In other words, multilingual acquisition/development deserves further attention of applied linguistic researchers and should become an important issue that is both intricately linked with and independent of SLA inquiries.

Last but not the least, certain degree of interplays between CAF components were identified within learners' writing of a single language as well as across learners' writing of different languages over time, and some interactions were

especially strong. Given that CAF have already been documented to be the most reliable indicators of language proficiency and language development, the present finding may further demonstrate that multilingual learners' different languages, as mirrored and measured by CAF in writing, are not in isolation, but rather, interactively bound up with each other over time. This interaction and independence of development in learners' multiple languages definitely conforms to the congenital characteristics of dynamic systems, i.e., all subsystems are integrative and are holistically interconnected to constitute a larger unified system.

## V. CONCLUSION

From a DST perspective, this study longitudinally probed the dynamic and interactive development of CAF in multilingual learners' L1, L2 and L3 writing over an academic year. Detailed analysis of the quantitative data shows that the developmental patterns of CAF in multilingual learners' (especially each individual learner's) L1, L2 and L3 writing were characterized by recurrent and elusive progression/regression, emergent and persistent changes, chaotic iteration, and by complex interactions among variables. Many implications can be drawn from this study, an important one being that, through exploring developmental trajectories and interplays of CAF in multilingual learners' (especially each individual learner's) writing, it justifies that multilingual development is indeed a dynamic and complicated process, which may supplement and provide further insights into forgoing and ongoing empirical studies and theories on multilingual acquisition/development. In addition, via adopting CAF dimensions to effectively capture the dynamics of multilingual learners' language development in writing, this investigation methodologically verifies that CAF, complexly integrative and interrelated constructs, can be used as valid indices of multilingual development and applied to the study of multilingualism.

However, this study, being exploratory in nature, did have its innate limitations. To begin with, we traced the development of CAF in multilingual learners' writing for only a 10-month period. In future research, a longitudinal corpus which covers a larger time span (e.g., 2-3 years) and includes denser data (e.g., data collected every month) is expected to shed more lights on the complex and dynamic patterns of multilingual development. Second, this study, following the canonical methods of DST (see, e.g., Marjolijn, Lowie, & de Bot, 2011), focuses on description rather than explanation of the language developmental processes. Revealing and explicating the reasons underlying these dynamic variations of multilingual development (e.g., why there is supportive and competitive relations between different measurements, why certain indices develop faster and more remarkable than others, what may be the possible internal/external factors that bring about these variations in multilingual development) fall within the major parameters of our ongoing and future inquiries.

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