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The Forum

# Differences and Similarities: Variability and Fractality in CDST

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*Variability* and *fractality*, two key concepts in Complex Dynamic Systems Theory (CDST)—the former concerning changes and variations, and the latter concerning recursiveness and self-similarities—may seem contradictory at first glance. This forum piece attempts to elucidate how the two seemingly contradictory properties can be reconciled in CDST to examine second language (L2) development. To that end, this piece includes a definition and short epistemological history of each concept, accompanied by a review of some relevant studies. It concludes with two metaphors to illustrate the relationship between *variability* and *fractality*, and how the two seemingly irreconcilable ideas can generate a clearer and more panoramic view of L2 development.

Imagine two identical twins born into the same family, living in the same household, receiving the same schooling, and having highly similar exposure to English. Many may think their L2 developmental route and patterns would be highly similar, if not identical. Yet, Chan et al. (2015) tracked the syntactic complexity of identical twins' L2 production and found that, despite genetic and environmental similarities, the twins showed contrasting development patterns over time in both oral and written production. The observation that both the process and the product of L2 learning tend to vary for both individuals or groups of learners despite similar language learning conditions is called *variability* (e.g., Robertson, 2000; Grüter et al., 2012). And even the L2 development of identical twins is no exception to this.

The concept of learner variability was first discussed in developmental psychology. Thelen and Smith (1994) were at the forefront of pointing out that variability in human development is an essential component of the learning process. They argued that as each individual develops, they will need to explore and try out each part of the process. This discovery journey, usually involving trial and error, progress, and regress, is an individual and erratic rather than a predetermined course. They pointed out that it is the change and transition from one state to another that matters, and these changes reveal much about how individuals develop: it is the very exploration of different steps that results in variability.

Aligned with how developmental psychology treats variability as an essential part of the learning process, L2 acquisition research linguists such as Larsen-Freeman (2012) also argued that "variability is intrinsic in complex, dynamic systems" (p. 104). Verspoor et al. (2021) posited that if we see L2 development as the result of the "complex and dynamically changing interactions of all influences that are relevant in this process," then variability is "the inherent manifestation of development and can provide information about the underlying process" (p.2). Instead of seeing variability as derailment or noise, L2 studies through a CDST perspective see it as a window to look into the learner development process. For example, Spoelman and Verspoor (2010) examined how Finnish learner language accuracy and complexity changed over time and found that the development of these measures was clearly non-linear and displayed different interrelations (competing or supporting) at different time points. However, over time no regular relationship was found between the accuracy and complexity measures. Similarly, Lowie and

Verspoor (2019) traced the changing writing quality of writing samples by 22 highly similar Dutch learners of English and found no two individuals developed in exactly the same way vis-à-vis their average sentence or word length. Both studies indicate that variability is widely observed in L2 development, and variability itself varies from one individual to another; that is, variability displays different patterns at different times in the L2 development of the same individual.

Despite the variability observed within and across learners, there are also similarities in the dynamic L2 language development. Larsen-Freeman (1997), for example, posited that "[a] pattern that exists at one level of scale holds for other levels and for the whole system" (p. 150). Further, Han et al. (2022) maintained that changes, small or large, have similar patterns and in a complex system like L2 development, the same mechanism works across all scales. This relates to the second concept in this forum piece, fractality, or the fractal property of a set of dynamic systems.

The term fractal was first coined by Benoit Mandelbrot (1975) for mathematical sets of numbers that stay present no matter at what scale they are viewed. A fractal is an irregular and never-ending pattern that repeats itself at different scales, and this property is called fractality or self-similarity (Schroeder & Herbich, 1996). Fractality can be found in nature (e.g., rivers, neural networks, tree roots), in algebra, in geometry, or in the nature of language (Larsen-Freeman & Cameron, 2008). Larsen-Freeman (1997) defined a fractal as "a geometric figure that is self-similar at different levels of scale" (p. 146), and used a tree to illustrate how fractality works. Think of how a tree grows and how a forest develops—a tree grows by repetitive branching and a forest develops by repeating the growth of one tree after another—and a fractal is made by the repetition of a process at different levels and different timescales, which means we can zoom in or zoom out (e.g., on different time scales or magnitude of measures) and find similar patterns.

Dynamic systems are nested (Han et al., 2022), which according to de Bot et al. (2007), means that "every system is always a part of another system…with the same dynamic principles operating at all levels" (p. 8), demonstrating recursive self-similarity. Fractal analysis is a powerful tool in investigating that recursive self-similarity. It observes and reveals the patterns and self-similarities of complex dynamic systems over iterative processes across multiple timescales (see, e.g., Stergiou, 2018). Evans (2020), for example, used fractal analysis to examine the extent to which the development of syntactic complexity in an L2 learner of English showed features of fractality at nested timescales. He found that as sub-constructs of syntax maintain their variability and complexity across different temporal scales, fractal scaling governs the use and development of syntactic complexity over time.

Now the question is: how can variability and fractality, two seemingly contradictory properties of language development, be reconciled in CDST? With some of her interpretations and expansions, the author of this piece will use Larsen-Freeman's (1997) tree example again, to metaphorically explain their relationship. In her illustration, trees grow into different shapes and sizes at different time points. It is practically impossible to predict the specifics of a tree or how many tree leaves a tree will be growing on a certain twig or branch, or from which twig or branch. The growth speed, dimension, and the number of tree leaves on different branches vary from tree to tree. From this metaphor, we can see that variability is widely existent within the same tree or among different trees. Nonetheless, it is not difficult to see how different parts of a tree are similar twig-wise or branch-wise, or how trees are similar dimension-wise or structure-wise—the similar growing pattern repeats itself at different magnification levels.

Like no two trees would grow in the same way, different language learners' interlanguages display different characteristics at different time points. Lowie and Verspoor (2019) pointedly argued that "no two individuals will develop in the same manner as development takes place in a nonlinear fashion" (p.185), and even identical twins are no exception to this (Chan et al., 2015). It is impossible to predict the exact development speed and the dimensions (e.g., syntactic complexity, lexical richness) of a particular learner's interlanguage, and each learner's interlanguage system and development vary. However, just as trees' similar growth patterns repeat themselves at different magnification levels, there are ways to observe and describe how learners' interlanguages might have developed out of similar variability patterns. By zooming in to first look at learners' marked intra-variability (e.g., individual-oriented case studies), and then proceeding to inter-variability, and zooming out to greater time scales through a longitudinal perspective, a clearer panoramic view of how smaller changes mirror larger changes to display self-similarities and how the same mechanism is working on all scales, will emerge.

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