Chaos Theory and Language Assessment: The effect of Sensitivity to Initial Conditions on Test Performance

Alireza Ahmadi
Department of Foreign Languages and Linguistics
Faculty of Literature and Humanities
Eram Paradise, Shiraz University
Shiraz, Iran

Abstract

Few studies have been conducted on the application of chaos theory to foreign language learning and assessment. The present study tried to empirically test the application of one of the fundamental tenets of the chaos theory (sensitivity to initial conditions) to language assessment by studying the effect that changing the first item of a MC test may have on test performance. Twenty Iranian EFL students majoring in English Literature at Shiraz University took part in the study. They were all freshmen who had just finished their first academic semester and were beginning the second semester. They took a MC grammar test of 2o items. After an interval of two weeks they took the same test in different versions. These versions were created by changing the first item that was presented to each student. The first item was; however, selected from the same test so that all the students received the same items, though, in different orders. Analyzing the results indicated that 72.21% of the students had a different performance on the second test. The results also indicated that 38.88% of the changes were considerably large (changes of 3 or more points in a scale of 0-20). The results were indicative of the effect of changing the first item of the test on test takers' performance in line with the idea of sensitivity to initial conditions in chaos theory.

Key terms: chaos theory, sensitivity to initial conditions, language assessment

1. Introduction

That language is a complex system in which a multitude of factors interact in known and unknown ways is a well-established fact. Many theories and models have been proposed and adopted in studying this complex system. An interesting theory which has been applied to the study of this intricacy is the "complexity" or "chaos theory". Chaos theory is a branch of study in applied mathematics which has found applications in other disciplines including physics, economics, biology, philosophy and language acquisition. The name chaos theory comes from the fact that the systems described by the theory are seemingly disordered, but chaos theory seeks to find the underlying order in the seemingly random data.

Chaos theory was formulated during the 1960s mostly by the efforts made by Edward Lorentz. He found that the slightest difference in initial conditions would make long-distant weather forecasts impossible to predict. Minute differences in weather conditions on a certain day will cause drastic differences after a few weeks, and these differences are basically impossible to predict. This phenomenon which is the cornerstone of chaos theory is known as *sensitivity to initial conditions*. It holds that a small change in the initial conditions may bring about a dramatic change in the long-term behavior of a system (de Bot, 2008, Larsen & Cameron, 2008). Many studies have been conducted from Lorentz's time on chaos theory and its application to different fields of study. In a seminal article on complexity which had a potential impact on the social sciences, Larsen-Freeman (1997) focused on chaos theory and its relation to SLA. She states that:

As is true of other dynamic nonlinear systems, language is also complex It satisfies both criteria of complexity first, it is composed of many different subsystems phonology, morphology, lexicon, syntax, semantics, pragmatics Second, the subsystems are interdependent. A change in any one of them can result in a change in the others (Larsen-Freeman 1989, 1991, 1994). In other words, the behavior of the whole emerges out of the interaction of the subsystems. Thus, describing each subsystem tells us about the subsystems, it does not do justice to the whole of language. Complex nonlinear systems exhibit sensitive dependence on their initial conditions, and language is no exception (Larsen-Freeman, 1997, p 149). Besides being a pioneer in this regard, Larsen-Freeman's work is one of a few studies conducted in the realm of second or foreign language acquisition. Following Larsen-Freeman, Finch (2004) focused on the implications of the complexity and chaos theory for EFL teachers and researchers.

Finch (ibid, p. 14) states that "the ELT/EFL class can be seen as an open system, with multiple subsystems (the participants). In this system, seemingly insignificant events can build up to critical thresholds, sparking sudden, irreversible shifts and new structures." This statement underscores the idea that even seemingly trivial points may create big and unexpected results which are of paramount importance. This idea is well-depicted in the concept of "sensitivity to initial conditions" in chaos theory. Other theoretical studies conducted in the realm of language teaching and learning using complex or chaos theory include Ellis, (2007), Finch, (2001), Feryok, (2010), Hadidi Tamjid, (2007), Harshbarger, (2007), Larsen-Freeman,(2002), Oekerman, (1997), Valle, (2000), and Swan, (2004). Unfortunately very few studies have overall been conducted on the application of complexity and chaos theory to language acquisition in general and foreign language learning in particular. This scarcity of research is more conspicuous when it comes to language assessment. To the best of researcher's knowledge no study has ever been conducted on the application of chaos theory to language assessment, mostly because "complexity in the EFL classroom continues to be difficult to research" (Finch, 2002, p.3). Furthermore, the studies conducted on language learning are of theoretical nature. Lack of empirical studies is greatly felt in this regard. As such, the present study can pave the way for empirical studies on the application of chaos theory to language learning and assessment especially in an EFL context. The fact that it is conducted in an Iranian EFL context, which is far lacking in this regard, can add to the necessity of this research.

2. Purpose of the study and research questions

The present study was an attempt at investigating the representation of chaos theory in language assessment. To do so; however, the study focused only on one of the major tenets of the chaos theory; that is, sensitivity to initial conditions. The study developed to investigate the effect of sensitivity to initial conditions on language test performance by studying the effect that changing the first item could have on test takers' performance. More specifically, the study was after the following question:

Does changing the first item of a MC test affect the test takers' performance?

3. Method

Participants

Twenty Iranian EFL students took part in this study. The participants, 6 males and 14 females, were all freshmen majoring in English Literature at Shiraz University, Iran. At the time of study, the participants had finished the first academic semester and were just at the beginning of their second semester. They all had passed a 4-credit course of grammar in the first semester and were thus familiar with the basic structure of the English language. Of course, the majority had attended English institute classes for several terms before coming to university and as such were not surely beginners in English. This is because Iranian students who seek admission to universities have to sit for the University Entrance Exam and compete for the vacant seats and therefore, those with a good level of English can enter universities to study foreign languages.

Instruments

The only instrument used in this study was a MC test of grammar. This test included 20 items of grammar constructed on the basis of the points that the students had covered in their grammar course in the previous semester. As such, it was a kind of achievement test measuring students' knowledge of grammar based on a specific course.

Data collection procedure

All the students received the test in one session. It took them about 15 minutes to finish the test. After an interval of two weeks, all the students took the same test again. This time; however, they received the same items of the test in different orders. That is, in the second administration, 20 different versions of the same test were administered to students. These versions were created by changing the first item that each student received. Therefore, each student received two versions of the same test; one was the fixed format which was the same for all the students, and one was the flexible version which was different from those of others in terms of the order of items.

Data analysis

The data collected were analyzed at two levels: individual and group. At the group level, the students' performance on the two versions of the test was subjected to a paired samples t-test to see whether the results of the two tests were significantly different or not?

In fact, this could indicate whether *sensitivity to initial conditions* of the chaos theory applied to language testing? This was possible by studying the effect of changing the first item on test takers' performance?

Following the same purpose the data were also analyzed for individual scores. That is, each student's performances on the two tests were compared to see how many students had higher or lower achievement when the first item they received was changed?

4. Results

Table 1 presents the descriptive statistics for the students' performance on the two versions of the test. As depicted in this table, the mean of the students on the flexible-format test is higher than that on the fixed-format test.

Table 1: Descriptive statistics of the performance on the two grammar tests

	Mean	Std. Deviation	Std. Error Mean
Fixed-format test	14.26	2.46	0.63
Flexible-format test	15.00	2.10	0.54

However, the results of a paired-samples t-test indicated that the difference was not significant. Table 2 depicts the results in this regard.

Table 2: Paired samples test for the performance on the two grammar tests

t	df	sig (2-tailed)
-1.14	19	0.27

The results of the paired-samples t-test indicated that the students had not significantly different scores on the two tests, but did this mean that the scores on the two tests were similar and therefore related. To find the answer to this question, Pearson correlation Coefficient was run.

Table 3: Pearson correlation coefficients for the performance on the two grammar tests

	N	Correlation	Sig.
Scores on Fixed-format test & Flexible-format test	20	0.41	0.12

Table 3 indicates that the correlation is not significant in this regard, meaning that the students' scores on the two tests are not meaningfully and significantly related. This means that although the t-test indicated that the overall performances of the students on the two tests were similar, this similarity only lay in the mean score of the group performance and the individual scores could be somehow different. As such, the scores were analyzed individually to see the possible changes due to the change in the order of the items. Table 4 indicates the results in this regard.

Table 4: Changes in scores from the fixed-format to the flexible-format test

Change type	No change	Increase in scores	Decrease in scores	Total change
	27.77%	44.44%	27.77%	72.21%

The table indicates that overall 72.21% of scores changed with a change in the order of items. Only 27.77% of scores had no changes. Of course not all the changes were big enough. In fact, 38.88% of the changes were big changes (changes of 3 or more points in a scale of 0-20).

VI. Discussion

The present study tried to put the chaos theory into empirical analysis. In doing so, however, the study only focused on one of the cornerstones of chaos theory, namely, sensitivity to initial conditions. It tried to see how this principle applies to language testing by studying the effect of changing the first item that students encountered in a MC test on their test performance. The results of the t-test indicated no significant effect in this regard. However, more specific analysis of the individual scores indicated that 72.21% of the students had a different performance after they received the same test with differing first items. Further analysis indicated that 38.88% of these changes were considerably big which could provide enough evidence for the effect of the order of presenting the items in a test.

According to the idea of sensitivity to initial conditions this effect could principally be assigned to the first item. It can be claimed that the first item has an influential role in determining how the students may perform on the following items. For example, depending on whether the students know the answer to the first item or not, it could affect them emotionally and this could affect their performance on the following items and hence their overall test performance would change. That's probably why many tests begin with easy items to prevent any negative emotional effect. This is especially true in power tests the purpose of which is to measure the test takers' ability level (Bachman, 1990).

Furthermore, when the first item changes, it may change the order of presentation of some other items as well. It's likely that different orders function in specific ways in creating a cognitive load for the test takers and this in turn may lead to more positives or negative results. In other words, each item elicits certain information and the interaction of the items in different orders may be different in a way that certain orders could be more or less demanding for students and therefore will lead to different levels of performance. However, the first item plays a more important role in this regard as it creates the first effect which may be more influential. This is the idea in chaos theory and its sensitivity to initial conditions based on which "small variations inherent in a complex system at a given point can result in large differences" (Harshbarger, 2007, p.3).

The findings of the study could be of importance to test developers. They should be very cautious as to which item to present as the first item in a test. In line with the *sensitivity to initial conditions in chaos theory*, a small and seemingly unimportant initial condition may create a big and unexpected outcome. Informing the teachers and students about such an effect may also help them in being more careful with the tests they make and in using the results of the tests. Awareness of such an effect may also help students to think of their own strategies in dealing with the emotional effect of the initial conditions.

IV. Limitations of the study

The present study may suffer from the fact that a small sample was used and probably that was the reason why t-test did not indicate a significant difference in the students' performance on the two tests. Meaningful differences may remain unexplored if the sample is very small and attention is only given to mean performance rather than the individual scores. The reason why the present study used such a small sample was the availability of the subjects and also the fact that it worked as an introductory study for a bigger main study.

References

Bachman, L. F. (1990). *Fundamental Considerations in Language Testing.* Oxford: Oxford University Press.

De Bot, K. (2008). Introduction: second language development as a dynamic process. *Modern Language Journal*, 92, 166-178.

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

Feryok, A. (2010). Language teacher cognitions: Complex dynamic systems? *System*, 38, 272-279.

Finch, A. E. (2001) Complexity in the language classroom. *Secondary Education Research*, *47*, 105-40.

Finch, A. E. (2002). *A systems view of the EFL class: Mapping complexity*. Retrieved January 23, 2010, from http://www.eslteachersboard.com/cgi-bin/articles/index.pl?read=909.

Finch, A. E. (2004). Complexity and systems theory: Implications for the EFL teacher/researcher. *Journal of Asia TEFL*, *1*(2), 27-46.

Hadidi Tamjid, N. (2007). Chaos/complexity theory in second language acquisition. *Novitas-Royal, 1*(1), 10-17.

Harshbarger, B. (2007). Chaos, complexity and language learning. *ICU Language Research Bulletin*, 22, 17-31.

Larsen-Freeman, D (1991). Teaching grammar. In M Celce-Murcia (ed), *Teaching English as a second or foreign language* (2nd ed, pp. 279-296.). New York: Newbury House.

Larsen-Freeman, D. (1989). Pedagogical descriptions of language grammar. *Annual Review of Applied Linguistics, 10*, 187-95.

Larsen-Freeman, D. (1994). Second language pedagogy grammar. *The Encyclopedia of Language and Linguistics,* Volume 7, Oxford Pergamon Press Limited.

Larsen-Freeman, D. (1997). Chaos/complexity science and second language acquisition. *Applied Linguistics*, *18*(2), 141-165.

Larsen-Freeman, D. (2002). Language acquisition and language use from a chaos/complexity theory perspective. In C. Kramsch (Ed.), *Language acquisition and socialization* (pp.33-46). London: Continuum International Publishing Group.

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

Oekerman, C. (1997). *Facilitating and learning at the edge of chaos: Expanding the context of experimental education*. Paper presented at the AEE International Conference. (ERIC document ED 414 142)

Swan, M. (2004). Complex quantum chaos and the present perfect. *ELT Journal, 58* (1), 68-70.

Valle, V. Jr. (2000). Chaos, complexity and deterrence. Technical Report, National War College, April 2000.