A dynamic systems theory approach to development of listening strategy use and listening performance

Jihua Dong a, b, *

a Foreign Language Department, Northwest A&F University, Yangling 712100, Shaanxi, China
b Department of Applied Language Studies and Linguistics, University of Auckland, Private Bag 92019, Auckland, New Zealand

ABSTRACT

This study investigated the developmental trajectories of an EFL learner's listening strategy use and listening performance and explored the dynamic correlation between the two variables from a dynamic systems perspective. A Chinese EFL learner's listening strategy use and listening performance were traced and examined every two weeks over a forty-week span. The data were analyzed using dynamic systems techniques including the moving min-max graph, Loess smoothing, variability, Monte Carlo technique, spline interpolation, moving window correlation and linear regression. It was found that the learner's listening strategy use and listening performance showed non-linear developmental patterns; regression in listening performance could predict progress to some extent; and the proximity of a new phase was characterized by great fluctuations and variability; there was a downward trend in the relationship between listening strategy use and listening performance over the study period. The analysis of the dynamic complex developmental path of individual listening strategies suggests a simplification, self-organization and self-adaptation process. The developmental patterns and dynamic correlations can provide insights into the interaction between listening strategies and listening performance in a dynamic system. The findings have valuable implications for theory construction and pedagogical practice relating to the development of listening strategies and performance.

© 2016 The Author. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

1. Introduction

According to Dynamic Systems Theory (DST), learners’ language development is a dynamic self-adaptation and self-restructuring process, in which “a set of variables mutually affect each other’s changes over time” (Van Geert, 1994, p.50). The DST perspective could unfold the development of language learning systems and reveal some features that remain elusive with traditional approaches. Its novel methods could also potentially accommodate the individual variations in a complex system, thus allowing us to trace how learners’ language competence develops during its interaction with other variables in a complex learning system (De Bot, Lowie, & Verspoor, 2007; Larsen-Freeman & Cameron, 2008; Jessner, 2008).

Within the DST framework, variability is generally regarded as a core element and notable feature in language developmental path of individual listening strategies suggests a simplification, self-organization and self-adaptation process. The developmental patterns and dynamic correlations can provide insights into the interaction between listening strategies and listening performance in a dynamic system. The findings have valuable implications for theory construction and pedagogical practice relating to the development of listening strategies and performance.

© 2016 The Author. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
(1) What are the dynamic developmental patterns of the EFL learner’s use of listening strategies influenced by listening strategy training?
How does the EFL learner’s listening performance develop in the course of interacting with listening strategies over the observation period?

What is the dynamic correlation between the learner’s listening strategy use and listening performance over the observation period?

2. Methodology

2.1. The participant

The participant in this study was a 23-year-old Chinese female postgraduate student majoring in engineering. She had learned English for about ten years when participating in this study, and had not been instructed with strategies systematically and explicitly. She passed CET 4 (College English Test Band 4) in her second year of undergraduate study, two years prior to the study. Her English score for the master entrance exam was 65 out of 100. In comparison with the peer students in her class, her English was at an intermediate level. According to her self-report, listening was the most difficult for her comparing with other skills such as reading, writing and speaking. During the study, she was preparing for CET 6 (College English Test Band 6). Therefore, she had a strong motivation to improve her listening proficiency, which was clearly displayed by her active engagement in this study.

2.2. Instruments

2.2.1. The listening strategies

The listening strategies used in the present study were mainly adapted from O’Malley and Chamot’s (1990) classification scheme. The reason for using the framework is that the classification scheme accords with people’s cognitive systems and has been widely applied in previous studies (Chamot, 2012; Chen, Zhang, & Liu, 2014; Crookes, Davis, & Locastro, 1994; Graham et al., 2008; Nation, 2001). In the strategy training, 21 listening strategies, representing three types of strategies, namely metacognitive, cognitive and social/affective strategies, were selected for training purpose. The detailed descriptions of the strategies are presented in Appendix A.

2.2.2. Listening strategies questionnaire

A questionnaire based on the 21 listening strategies was administered to assess the student’s strategy use every two weeks. The listening strategies questionnaire was mainly adapted from Vandergrift’s (2006) metacognitive awareness listening questionnaire (MALQ) and O’Malley and Chamot’s (1990) strategies classification scheme. The questionnaire was conducted in both English and Chinese for the purpose of better showing the student’s listening strategy use (see Appendix B). In order to ensure that the student could fully understand the question items, every item was explained with examples before the questionnaire investigation. The items were measured on five-point Likert scales ranging from 1 to 5 (1 = never, 2 = seldom, 3 = sometimes, 4 = often, and 5 = always). Students’ strategy use levels were based on Oxford’s (1990) rating scale (See Table 1). The questionnaire has been employed in a previous study and the Cronbach’s Alpha was 0.876, indicating that the questionnaire has a relatively high reliability.

2.2.3. Diaries

In conjunction with the listening strategies questionnaire, the listener was also required to keep diaries in Chinese for the sake of better elicitation of her reflections every two weeks. The reason for employing listening diaries is that diary is a useful means to elicit learners’ reflections and develop their listening process awareness (Vandergrift, 2007). The prompts of the listening diary mainly centered on her reflections on the use of the listening strategies in her listening activities, such as “How do you feel in using the listening strategies”, “Did you have any difficulty in using the strategies? If so, what are they?” and “What do you think of the role of strategies in your listening activities?”

2.2.4. Listening materials

The listening materials used in the in-class and after-class exercises were chosen from the textbook Graduate English for the 21st Century Listening published by Xi’an Jiao Tong University Press, 2008. The listening tests used to assess students’ listening performance were adapted from the model test of CET 6 released by Shanghai Foreign Language Education Press. CET 6 is a national English test designed for college students in China. In this study, 21 different test papers were employed to assess the

<table>
<thead>
<tr>
<th>Level</th>
<th>Description of strategy use frequency</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Always or almost always used</td>
<td>4.5–5.0</td>
</tr>
<tr>
<td></td>
<td>Generally used</td>
<td>3.5–4.4</td>
</tr>
<tr>
<td>Medium</td>
<td>Sometimes used</td>
<td>2.5–3.4</td>
</tr>
<tr>
<td>Low</td>
<td>Generally not used</td>
<td>1.5–2.4</td>
</tr>
<tr>
<td></td>
<td>Never or almost never used</td>
<td>1.0–1.4</td>
</tr>
</tbody>
</table>
student’s listening performance. Given that the test papers were all designed following the standard of CET 6, it could be assumed that the test versions were homogeneous in the level of difficulty.

The listening test papers consisted of the following four sections: short conversation, long conversation, passage comprehension and compound dictation. One modification was made in the test papers by adding one compound dictation section, because the participant reported this section was the most difficult part for her and had expressed a strong desire to have more practice on this section. One sample of the tests is shown in Appendix C.

As the listening test was adapted from the listening model test, the numbering of the test items was kept as 11–57 following the original order, for there is a skimming & scanning section before the listening section in the CET 6 test papers. The test consisted of multiple choice (sections A and B, items 11–35) single-word cloze (section C, items 36–43 and 47–54), and sentential cloze questions (section C, items 44–46 and 55–57). Multiple choice questions counted for two points per question, single-word cloze counted for one point per question, and sentential cloze counted for four points per question. The tests of listening performance were marked by two English teachers who taught post-graduate English courses. In order to determine the agreement between the two raters, the scores given by the two teachers were analyzed using Cohen’s kappa with SPSS, and the alpha of intra-rater reliability of the coding was 0.96, indicating a relatively high agreement between the two raters. Averages of the two raters’ scores were calculated for cloze items and combined with subtotals of the multiple-choice items. A full score on the exam was 90 points.

2.3. Procedure

According to Chamot, Barnhardt, El-Dinary, Carbonaro, and Robbins (1993), implementing strategy training gradually over an extended period of time enhances the effectiveness of students’ strategy learning. Therefore, the present study conducted the strategy training over 13 weeks, and examined the learner’s listening strategy use and her listening performance development over 40 weeks, inclusive of the training period.

The listening strategy training was conducted by following the strategy training model proposed by O’Malley and Chamot (1990). To be specific, the researcher first demonstrated how to use the listening strategy with a “think-aloud” technique in the designed listening activities and guided her to use the specific strategies in the listening activities. The reason for using “think-aloud” in the class demo is that this approach could simulate the cognitive process of applying the listening strategies while processing the audio information, and it could also bring to the surface the complex cognitive processes underlying the elusive listening activity.

In order to consolidate the strategies learned in class, three after-class exercises were assigned to the participant each week. In the assigned listening tasks, the specific listening strategies embedded in the listening tasks were explicitly noted in the first 14 weeks when she was instructed with the strategies. For example, after the first session when planning, directed attention and selective attention strategies were trained, the student was required to practice the three strategies learned in her assigned listening tasks. From week 16 onwards, the student was required to select strategies by herself and report the strategies she used, instead of being assigned with the specific strategies in the listening tasks, for the purpose of practicing her skills in identifying and using strategies in the listening tasks.

In order to trace the participant’s strategy use and listening performance, the two variables were measured every two weeks. The assessment was conducted every other Friday, lasting for 45 min. Following the assessment, a questionnaire was administered to investigate her listening strategy use in processing the tasks. After that, the student was required to write her reflections guided by the prompts as shown in Section 2.2. The first assessment and survey took place in the week prior to the strategies instruction, for the purpose of investigating the student’s initial listening proficiency and prior knowledge of listening strategies. Then, the assessment and survey were carried out every other week from week 2 onwards. In total, this study collected 63 pieces of data concerning the participants’ listening strategy use, listening scores and dairies (2 pieces for each).

In the data analysis, this study employed the following dynamic systems-based techniques in the process of investigating the development of the learner’s use of listening strategies and listening performance, and exploring the dynamic interaction between the two variables.

2.3.1. The moving min-max graph

The moving min-max graph (Van Geert & Van Dijk, 2002) was employed to detect the temporary changes and the degree of variation in the development of the two variables. The moving min-max graph is a descriptive approach to visualize the variability and highlight the general developmental patterns of the variability (Verspoor, De Bot, & Lowie, 2011).

As it plots the moving minima, maxima, and observed values of the variables, the moving min-max graph highlights “the general pattern of variability, while keeping the raw data visible” (Verspoor et al., 2011, p.75). Thus, it was applied to examining the general developmental pattern of listening strategy use and listening performance for the purpose of obtaining an overall picture of the developmental patterns of the two variables. The predetermined moving window span chosen in this study was three consecutive measurement points with the aim of obtaining a relatively detailed picture of the developmental patterns.

2.3.2. Loess smoothing

In order to depict the general and underlying developmental trends of the student’s listening strategy use and listening performance, we plotted the Loess curve, locally weighted least-squares smoothing (Bassano & van Geert, 2007; Simonoff, 1996), across the data of the listening strategies and listening performance. Given that Loess is achieved by “weighting the
data proportional to their distance from the middle of the window” (Bassano & van Geert, 2007, p.595; Simonoff, 1996), it serves as an efficient descriptive and exploratory tool for modelling complex and uncertain processes for which neither developmental patterns nor theoretical models exist (Jacoby, 2000). Therefore, this study employed this technique to explore the complex developmental trajectories of the individual listening strategies. In carrying out Loess smoothing, this study used PTS LOESS Smoothing Utility (Peltier, 2009). The smoothing parameter alpha $\alpha$ was set to be 0.33, thus the moving window being 7 observation points, to allow the smoothed curves to better display the general patterns while showing the local patterns of the variations.

2.3.3. Variability

This study also calculated the variability of the two variables in order to find the developmental state of the learner’s listening and her adaptability to the changing environment. Between-session and residual variability approaches were employed in this study. Between-session variability is concerned with the difference between an observation and the preceding observation of a variable (Bassano & van Geert, 2007). It is calculated based on the absolute differences between the consecutive measurement points over time. Residual variability refers to the distance between an expected value (the value on the Loess smoothing trajectory) and the observed value (the raw value) (Bassano & van Geert, 2007). As a supplement to the phase transitions revealed by the between-session variability, residual variability measures the extent to which an observed value deviate from an expected value based on the smooth curve. Thus, it could reveal the emergence of growth spurts that are much higher than the growth model would predict. The predictive model used to derive estimates and residuals was based on the Loess smoothing approximation. The residuals were obtained by calculating the distance between the actual observations and the expected values on the smoothed curve.

When analysing the three types of listening strategies, we used between-session variability in order to illustrate the temporary changes in variability and explore the variability peak in the listening strategy developmental trajectory. As for the variability analysis of the listening performance, we used the between-session variability to detect a developmental transition in the learner's listening development and residual variability to visualize the degree of fluctuations of the listening performance with the expected value.

2.3.4. Monte Carlo technique

In the statistical analysis, the Monte Carlo (random permutation) technique (Van Geert, Steenbeek, & Kunnen, 2012) was used to calculate if there is any statistical significance in the differences observed in the developmental trajectories. The statistical technique is appropriate for the observations in this study, and the $p$-value calculated by this technique “very closely approach[es] the expected $p$-value and will thus be reliable, irrespective of the strangeness of the sample” (van Geert et al., 2012, p.46).

2.3.5. Spline interpolation

When analysing the correlation of the listening strategy use and the listening performance, we used spline interpolation combined with a smoothing operation for the purpose of visualising the dynamic interaction between the two variables. The spline interpolation trajectories also provide clues for defining the window size of the moving window correlation as discussed below.

2.3.6. Moving window correlation

In order to explore the dynamic relationship between the two variables, this study analyzed the dynamic correlation between the learner’s listening strategy use and listening performance by employing a moving window technique and then plotted the moving correlation trajectory over the study period.

2.3.7. Linear regression

For the purpose of providing statistical support for the correlation shown in the spline interpolation trajectory and the moving window correlation, we calculated the linear regression for listening strategies and listening performance.

3. Results and discussion

3.1. The developmental patterns of listening strategy use

The trajectory of the student’s listening strategy use and the min-max values are illustrated in Fig. 1. It is clear that the student’s listening strategy use followed a noticeable non-linear pattern. In other words, the development of the listening strategy use did not remain stable in the course of the trajectory. As illustrated by the developmental trajectory, the learner’s listening strategy use was characterized by a temporal overshoot in the initial stage of strategy training. Then her strategies remained at a relatively high level from week 8–22, which was followed by a gradual downward trend from week 24

---

1 The size of the moving window comprises the $n \times \alpha$ points (rounded to the next largest integer). $N$ represents the number of dataset and $\alpha$ represents the smoothing parameter.
onwards, and eventually moved to a final period of stabilization. It is interesting to note that although the strategies leveled off towards the end, it was still much higher than the use prior to the strategy training. Overall, the learner’s strategy learning trajectory shows periods of progress and regression rather than a neat linear developmental path. The non-linear developmental pattern of listening strategies is in accordance with the findings in previous studies (Alibali, 1999; Church & Goldin-Meadow, 1986; Siegler, 2006; Siegler & Svetina, 2002).

As shown by the max-graph, the learner’s listening strategy use seemed to undertake three noticeable phases. Specifically, in the first phase, mainly from week 0 to week 6, the learner’s strategy use increased gradually. The second phase, from week 8–22, saw a relatively steady progress in the learner’s strategy use, which was followed by a gradual decrease and stabilization in the third phase from week 24 onwards. In order to test if there are statistical differences in the learner’s listening strategy use among the three phases shown in Fig. 1, we employed the Monte Carlo analysis to compare the strategy use among the three phases with respect to each other (A conventional significance level (p = 0.05) was used for the Monte Carlo comparative analysis). The analysis showed that the strategy use in the second phase was significantly higher than the first phase (p = 0.0002); and the third phase was significantly higher than the first phase (p = 0.01). However, the difference in strategy use between the second and third phases did not reach significance (p = 0.061). The result partially corroborates the division of the three phases revealed by the min-max graph. The result may indicate that phase transitions may be an inherent characteristic of learners’ listening strategy developmental pattern. The result supports the findings on the relationship between nonlinear development and phase transition revealed in previous dynamic systems-based studies (Baba & Nitta, 2014; Fischer & Yan, 2002).

In order to obtain a detailed picture of the dynamic developmental features of listening strategies, the 21 listening strategies were examined separately. The following section reports the strategies development from the perspective of three categories of listening strategies, namely metacognitive, cognitive and social/affective strategies in detail.

3.1.1. The developmental trajectories of metacognitive strategies

This section presents the raw data and the Loess smoothing trajectories of each metacognitive strategies. Considering that variability is “a potential driving force of development and a potential indicator of ongoing processes” (Van Geert & Van Dijk, 2002, p.341), we also explored the intra-individual variability of the learner’s metacognitive strategies for the purpose of identifying the peaks in the developmental variability and exploring its relationship with phase transitions.

First of all, in order to depict the general trend of the student’s listening strategy development, we plotted the Loess curves across the data of the metacognitive strategies. As shown in Fig. 2(a)–(g), the student’s the metacognitive strategy development trajectories were characterized by noticeable diversity and complexity.

The analysis shows that there were some interesting patterns in the smoothed curves of the metacognitive strategies. First, the strategy used prior to the strategy instruction, like planning, as in Fig. 2(a), and problem identification, as in Fig. 2(f), tended to experience steady growth after week 1 and 5 when the two strategies were instructed respectively. In contrast, the strategies not used before, like self-monitoring, as in Fig. 2(e), and self-evaluation, as in Fig. 2(g), experienced intense fluctuations in the first few weeks after the strategy training in week 3 and 5 respectively. Interestingly, despite the similar variability experienced in the initial stage after strategy training, the strategies were found to end up with diverse patterns. For instance, self-evaluation, as in Fig. 2(g), underwent great fluctuations since week 5 when it was instructed and then moved on to a phase with relatively high use from week 26 onwards, while directed attention, as in Fig. 2(b), was found to be used at a medium level in the later stage of the study. However, strategies like self-management, as in Fig. 2(d), and self-monitoring, as in Fig. 2(e), also went through dramatic fluctuations after being taught, but then ended up with a low level of use towards the end. Overall, the results indicate that the strategies with prior use tended to develop relatively smoothly after the strategy instruction, while the strategies not used before seemed to experience great fluctuations during the initial stage.
In order to find how metacognitive strategies fluctuate over time, we calculated the variability of the metacognitive strategies. Fig. 2(h) shows several peaks emerged in the variability trajectory of the metacognitive strategies. The first and the highest peak emerged in week 4 following the rapid growth in the initial stage, and the second major peak took place in week 14, which was followed by two relatively small peaks in week 22 and 28 respectively. It is interesting to note that the second major peak coincided with the finishing point of listening strategy training, which may indicate that the strategy training seemed to have some impacts on the variability of metacognitive strategies. As discussed in Section 3.1, week 22 was breakpoint between phase 2 and 3 of listening strategies trajectory, the co-occurrence between the peak and the phase transition boundary suggests that great variability is likely to happen around the proximity of phase transitions. The finding provides empirical evidence for the theoretical assertions that variability is an indicator of a phase transition (Van der Maas & Molenaar, 1992; Van Geert & Van Dijk, 2002).
3.1.2. The developmental trajectories of cognitive strategies

The raw data and smoothed trajectories of the individual cognitive strategies are illustrated in Fig. 3 (a)–(j). The analysis shows that the cognitive strategies displayed the following notable characteristics. First of all, the participant used more cognitive strategies than metacognitive strategies. One of the possible reasons is that cognitive strategies mainly deal with the materials (O’Malley & Chamot, 1990), and it is possible that some of the strategies may have been taught or acquired in the learner’s previous experience, and then transferred into her listening activities. For instance, the student reported that she

![Fig. 3. The dynamic developmental trajectories of cognitive strategies](image-url)

Note: \(\rightarrow\) represents the raw data; \(\rightarrow\) represents Loess smoothing curve; \(\rightarrow\) represents the variability.
had employed note-taking strategy in the previous learning experience, thus transferred this strategy to listening activities in processing the audio information.

Secondly, the analysis indicates that the cognitive strategies used before increased to a higher level of use in the initial period after the strategy training. For instance, repetition, as in Fig. 3(a), and summarizing, as in Fig. 3(h), which had been used prior to the strategies instruction, were found to go through substantial increase after the training and remain at a relatively high level in the following weeks. Similarly, the use of grouping, as in Fig. 3(c), and deduction/induction, as in Fig. 3(e), also started with initial use, and increased substantially with minor fluctuations after the instruction. However, the analysis of their developmental trajectories in the later stage indicates that there was no noticeable phase division revealed in the trajectory of grouping strategy, while deduction/induction strategy was found to end up with a much lower level of use towards the end. In order to see if there were statistical differences between the two phases shown by the smoothed curve in Fig. 3(e), we employed the Monte Carlo technique with 5000 simulations (shuffled permutation). The result shows that there were significant differences between the period from week 26 onwards and the previous phase \( p = 0.002 \), which indicates that deduction/induction strategy was used significantly less frequently towards the end of the study period. The divergent use of the two strategies may reflect that prior knowledge, despite its boosting effect in the initial stage, does not guarantee the high-level use towards the end.

Overall, the finding suggests that prior knowledge plays an important role in enhancing the strategy use to a higher level with the boost of strategy training. In other words, the student was inclined to pick up the familiar strategies and consolidate their use in the listening activity. The importance of prior knowledge is in accord with recent findings indicating the role that initial states play in the developmental process of a complex system (De Bot et al., 2007; Lowie, Verspoor, & Bot, 2009, pp. 125–145; Verspoor et al., 2008). According to De Bot et al. (2007), the development of dynamic systems has a high dependence on their initial states, and minor differences during the initial phase may result in “dramatic consequences in the long run” (p.8). Lowie et al. (2009, pp. 125–145) also stress that “language development is dependent on the initial condition and shaped by a wide range of interacted factors in a dynamic way” (p.126). Similarly, Verspoor et al. (2008) highlight the importance of initial states in the dynamic development of systems, and view initial states as the basis of a system development.

Thirdly, with respect to the strategies reported not used before, their development trajectories displayed intense fluctuations in the first few weeks. For example, key words, as in Fig. 3(f), and inferencing, as in Fig. 3(j), underwent great fluctuations in the first few weeks after strategy training, but rose and then remained at a high level towards the end. Similarly, the resourcing, as in Fig. 3(b), and elaboration, as in Fig. 3(g), spiraled upward toward a high level after the strategy training, but ended up with a medium level towards the end of the study period. Hence, it could be conceivably hypothesised that the “never-used” strategies were more likely to undergo great fluctuations and complexities after the strategy training.

When examining fluctuations of the strategies reported not used before, we also calculated the between-session variability (the sum of the distances between consecutive measurements), and the result is presented in Fig. 3(k). As illustrated by the trajectory, the four strategies never used before, namely resourcing, key words, elaboration and inferencing underwent great fluctuations. The highest peak emerged in week 10 when elaboration and inferencing were just trained, and the peak of variability continued until week 14. The intense variability of the four strategies in this period shows that the lack of prior knowledge may hinder the use of these strategies in the first few weeks after the strategy training. The second highest peak in variability occurred in week 22, which coincided with the breakpoint between phase 2 and 3 as discussed in Section 3.1. The result may indicate that variability tends to work as an indicator of phase transition.

Fig. 3(l) illustrates the dynamic developmental variability pattern of the learner’s use of cognitive strategies. An indicated by the developmental trajectory, the first peak emerged in week 6 proceeded by a rapid growth in the variability of cognitive strategies, while the highest peak occurred in week 22. As discussed in Section 3.1, week 22 was a breakpoint between phase 2 and 3 of strategy use, the co-occurring of variability peak with the phase boundary suggests that great fluctuations and variability tended to emerge during the phase transitional period. The finding corresponds to the hypothesis that the proximity of phase transition is accompanied by great variability in the development of systems (Van der Maas & Molenaar, 1992; Van Geert & Van Dijk, 2002).

3.1.3. The developmental trajectories of social/affective strategies

In contrast with the diverse patterns illustrated above, the developmental trajectory of individual social/affective strategies (Fig. 4) shows roughly similar patterns within the four strategies. Clearly, the student’s use of the four strategies increased notably to a high level of use after the instruction from week 14 onwards. Such increase, on the one hand, could reflect the effectiveness of the listening strategy instruction, as listening strategy training not only increases learners’ listening strategy awareness but also equip them with the skills in carrying out listening activities. On the other hand, the higher use of the social/affective strategies suggests that the student seemed to have encountered difficulties in carrying out listening activities. As shown by analysis of surveys and diary entries during this period, the student often resorted to the social/affective strategies in order to gain confidence to better fulfil the listening tasks. In this light, the social/affective strategies could be regarded as compensatory strategies students employ to deal with the challenging listening tasks.

Despite the initial sharp increase after the strategy training, the student’s social/affective strategy use was found to decrease in the final stage of the experiment. Specifically, the affective strategies, including self-talk and self-reinforcement strategies, were found to regress to a medium or even low level in the final stage. To test if there are statistically significant differences in the use of the two strategies in different phases, we used the Monte Carlo technique. The result revealed that
self-talk and self-reinforcement strategies were employed significantly less frequently towards the end of the study from week 32 onwards than the previous phase \((p = 0.035\) and \(0.004\) respectively). Given that affective strategies could provide affective support for learners to cope with the difficult listening tasks, the decreasing reliance on the affective indicates that the learner may become more efficient and independent in processing listening tasks in this phase. Likewise, the social strategies including question for clarification and cooperation strategies, were also found to decrease in the later stage of this study. One of the possible explanations for such decrease may be that listening is generally regarded as an individual activity rather than group behaviour. Although the training and after-class exercises enhanced the strategy use substantially, the student tended to decrease or even give up the social strategies possibly because the listening tasks do not require social interaction, which on the other hand may suggest a self-organization and self-adaption process in the learner’s strategy use as will be discussed below.

The trajectories of the affective strategies correspond to the student’s reflective diary entries regarding the use of the two strategies. For instance, in week 22 she commented that “I use self-talk strategy a lot. When I am unable to concentrate, I talk to myself to stay focused. When I couldn’t follow the listening information, I tell myself to not to give up and attend to the following information. I find the strategy very helpful, as it makes me more confident.” However, later in week 32, the student wrote, “I sometimes talk to myself, but far less often than before, maybe because I become more concentrative. I don’t think that I have enough time to talk to myself during listening when I am dealing with the information.” Similarly, the learner wrote about her use of the self-reinforcement strategy in week 16, “I like using the self-reinforcement strategy. I often reward myself with a small gift when doing the tasks well”. However, towards the end of the study, she seldom mentioned the strategy in her diaries, except in one comment in week 36 “I do not bother to treat myself with a reward now. It is natural for me to do well in my listening”. Clearly, those diary entries provide evidence that the learner employed the social/affective strategies during the initial stage of learning the strategies, but stopped using them towards the end. In this sense, these strategies seem to play a central role in assisting her carrying out listening activities during a particular period of the system development.

An examination of the overall strategies indicates that the student’s use of listening strategies was characterized by a complex developmental pattern. Some strategies, such as repetition and summarizing strategies, increased and remained stable at a high level, while some strategies, like self-talk and self-reinforcement strategies, were frequently used during the initial stage of learning, then experienced a rapid increase and eventually disappeared towards the end. The learner’s listening strategy use patterns correspond with Siegler’s (1996) overlapping waves model which assumes that learners employ various strategies at any point of their problem solving, thus taking on the appearance of a series of overlapping waves.

It can thus be suggested that the overall dynamic developmental patterns of listening strategies represented a dynamic self-adaptation, self-organization and simplification process in the course of employing strategies. As shown by the trajectories of the overall strategy use, the student’s strategy use increased after the strategies instruction and then reached a peak.
However, the analysis of the strategies used in the final stage shows that the learner ended up using only a few strategies to process the listening tasks. The result may suggest that the learner tended to select or decide on the strategies that suit their own listening activity after being instructed with a wide range of strategies. In other words, in the course of using strategies the student seemed to have tried the strategies, tailored the strategies to her own listening practice and finally developed her own strategy preference. Over the dynamic process, she tended to adapt her listening strategies to fit her needs in processing the listening tasks. The simplified set of strategies, in turn, could allow her to allocate more attentional resources to the listening tasks, rather than oscillate around which strategies to choose. The finding confirms Cohen and Stewart’s (2000) statement that “emergence produces simplicity from complexity”. The self-adaptation is found to be “itself evolving” when interacting with the changing contexts (Larsen-Freeman & Cameron, 2008). The finding also parallels the statement that the development of learners’ complexity, fluency and accuracy shows a process of self-adaptation to changing environment (Larsen-Freeman, 2006).

3.2. The developmental pattern of listening performance

Fig. 5 shows the developmental trajectory and moving min–max graph of listening performance. As can be observed, the trajectory of listening performance shows that the student’s listening performance was accompanied by salient fluctuations over the forty-week span. In other words, the trajectory of the learner’s listening performance was characterized by an alternation of progress and regression instead of a linear developmental path.

Several noticeable regressions were revealed in the trajectory of the listening performance. The regression in listening performance could be explained by “resource competition” (Larsen-Freeman, 2009) during the interaction with listening strategies. As shown by the diary analysis, the learner tended to allocate her attentional resources to predicting the audio information, picking up the ongoing materials and reading the questions, whilst selecting the suitable strategies in the course of processing the listening tasks. For example, the student commented that “The listening activity is very intense. During listening, I read the given items, and predict the possible episode and questions. I find it very hard to select the appropriate strategies and capture the audio information at the same time. When I am selecting the appropriate strategies to use, I often miss the audio information.”

Judging from the above diary entries, it seems that the synchronous operation of the multiple tasks may cause competition in the brain to shift part of attentional resources towards identifying the appropriate strategies and employing them properly. Given that attention resources may be decided the moment when listeners’ attention tuned into selecting strategies, the learner might neglect some of the upcoming information. This is particularly the case with the audio information, which is stored in short-term memory and might elapse before being transferred into long-term memory. As a consequence of the competition between the conscious use of the strategies and the attention focusing on the upcoming information, the learner may find a temporary drawback in using listening strategies to process the audio tasks.

Meanwhile, the trajectory also shows an interesting relationship between regression and progress. As illustrated by Fig. 5, two notable regressions took place around week 14 and 22, each of which was followed by remarkable progress in the subsequent weeks. Specifically, the student’s listening score decreased substantially in week 14, which was followed by an increase between week 16 and 18. Similarly, her listening score in week 24 reached a peak, following a temporary decrease in week 22. The result may imply that regression could predict progress to some extent. In other words, regression may be a sign of progressing or updating to a higher level of language development. The dairy analysis reveals some comments corresponding to the fluctuations during the period. For instance, the student wrote in week 14 that “I find it disturbing to use the listening strategies during listening. When I was trying to find out which strategy to use, I missed the audio information.” Similar worries were also expressed in the diary in week 22, “At the beginning of the test, I was searching for the suitable strategies to use, and I missed the beginning of the audio information. I became very nervous, and found it very hard to concentrate.” As suggested in the diary in the following week, the learner seemed to explore a way to improve the situation.

![Fig. 5. The developmental trajectory and moving min–max graph of listening performance.](image-url)
because she wrote “When self-evaluating my listening comprehension, I realise that if I can find the suitable strategies and feel comfortable at the beginning, I often capture the listening material easily. Otherwise, I often ended up with feeling very worried. (...) I made a decision to use whatever strategies come to my mind first. I think this is good because it saves time. Now I choose to pay more attention to the listening tasks than to listening strategies”. These diary entries indicate that the regression may manifest the learner’s free exploration and resilience in applying the listening strategies to her listening activities. In other words, the temporary drawback in listening performance, from a dynamic viewpoint, reflects the learner’s self-organizing and self-adapting to the new phase in the dynamic interaction within systems, as the regression tended to spur learners to take measures to explore the suitable strategies, thus contributing to advancing their listening comprehension to a higher level. The finding is in accordance with Baba and Nitta’s (2014) statement that a small push often drives a system to another state. Verspoor and Smiskova (2012) also find that regression reflects learner’s “flexible and adaptive behaviour” and allows them to explore freely the strategies to be used in the system development. Therefore, fluctuations “probe the stability of the system, allowing it to discover new and different ways to solve problems” (Kelso, 1997, p.11) and provide the momentum for the development of dynamic systems.

It has been suggested that the min-max graph could show the dynamic stability in learners’ language acquisition (Larsen-Freeman & Cameron, 2008; Van Geert & Van Dijk, 2002). Thus the present study analyzed the moving min-max graph of the student’s listening performance and the result is presented in Fig. 5. As shown by the min-max value, the learner’s listening performance displayed the following noticeable developmental phases. In the first phase, the student’s listening performance rose steadily to a relatively higher level. From week 4–18, the student’s listening scores developed relatively steadily, despite the mild fluctuations as shown by the listening performance path. The max trajectory from week 20 onwards shows that the student’s listening performance moved to a high-level stable development period.

It is worthwhile to point out that the listener’s listening performance displayed the following relationships between the fluctuations and phase transitions. For one thing, the proximities of the phase transitions in listening performance tended to be accompanied by overt fluctuations. For instance, the most obvious variation, which emerged at the around week 20, was followed by a relative stable phase as shown in the max trajectory. The great fluctuations that accompany the period of a phase transition echo Siegler’s (2006) statement that the phase transitions are characterized by high variability. The finding supports the statement that variability indicates a transition towards a new attractor state (Bassano & Van Geert, 2007; Van Dijk & Van Geert, 2007). The result is also in line with the finding that large variability increases during the initial stage of learning and then tails off as learners develop more advanced L2 systems (Cancino et al., 1978; Ellis, 1994; Verspoor et al., 2008).

Additionally, the accumulation of the variation in the relatively stable phase, in turn, may give rise to the qualitative shift to a new phase. As revealed by the trajectory of the learner’s listening performance development, dramatic fluctuations were often followed by the phase transition which symbolized the arrival of a new phase. In other words, the intense fluctuations could possibly usher in a long-term stable development phase in which transitional change would not easily occur, but rather accompanied with minor variability. According to Verspoor et al. (2008) and Spoelman and Verspoor (2010), phase transition is a common phenomenon in language learners’ proficiency development, which is characterized by “qualitative change in the attractor” (Baba & Nitta, 2014; Bardy, Oullier, Bootsma, & Stoffregen, 2002). The intense variability around phase transitions provides evidence for the statement that increased variability serves as an indicator of an imminent discontinuity of phase shift (Bassano & Van Geert, 2007; Van der Maas & Molenaar, 1992; Van Dijk & Van Geert, 2007). The finding is also in accordance with Beckner et al.’s (2009) claim that “quantitative difference leads to phase transition”. Lowie et al. (2009, pp. 125–145) also suggest that variation could enable evolution as it allows the variables to “adapt to changing conditions” (p.127), due to the impetus provided by the interaction with various factors in a new phase.

In order to explore the relationship between variability and phase transition in the learner’s listening development, we plotted the variability trajectory of her listening performance. As shown in Fig. 6 (a), the first peak in between-session variability emerged in week 12, while the highest peak occurred in week 22, showing that the learner’s listening performance underwent intense fluctuations in the two weeks. It is surprising to note that the variability peaks coincided with some peaks in the variability trajectories of strategies and also showed agreement with the phase breakpoints as discussed in Section 3.1. The result indicates that variability seems to be a critical feature of phase transition in a system development. The result provides evidence for Van Dijk and Hacker’s (2003) assumption that variability indicates a specific moment in the presence of a developmental transition.

Also, we calculated the residual variability to compare the listening performance with the smoothed approximation, and the result is illustrated in Fig. 6 (b). As illustrated by the residual variability trajectory, the first peak emerged in week 14, and the second residual variability peak emerged in week 24, which were just one observing point after the peaks revealed by the between-session variability trajectory. Thus, the residual variability peaks roughly correspond to the rapid growth as shown by the between-session variability in Fig. 6 (a). The result regarding the residual variability and the between-session variability in line with the finding reached in Bassano and Van (2007). The results reflect that week 14 and 24 were two critical points in the learner’s listening performance development when the degree of the variations is much higher than the predictive model would estimate. It is also interesting to note that week 14 and 24 were two breakpoints of phases in the learner’s listening performance development as will be illustrated by the spline interpolation in Fig. 7. Thus, the result may indicate that the variability in the listening performance development may symbolize the arrival of phase transitions. According to Van Geert and Van Dijk (2002), variability serves as the “harbinger of change” (p.342), as it not only provides a driving force for learners’ free exploration but also indicates that the system may move to another phase of development.
3.3. The correlation between listening strategies and listening performance

When exploring the relationship between listening strategies and listening performance, we used the spline interpolation to generate the developmental trajectories of two variables and plotted the moving window correlation to show the statistical correlation between the two variables over time.

Fig. 6 illustrates the spline interpolated trajectories of the learner’s listening strategy use and listening performance. As can be found, the student’s listening strategies and listening performance mainly underwent three seemingly co-occurring phases, namely the first phase lasting from beginning to week 12, the second phase from week 14 to 22, and the third from 24 to 40.

The first phase saw a gradual increase and a relatively stable development in both listening strategy use and listening performance, and the statistical analysis shows that the two variables were statistically correlated in the first stage ($r = 0.965$, $p = 0.000$). However, in the second phase, both listening strategy use and listening performance development were characterized by noticeable fluctuations. The ups and downs illustrated in this phase could, to some extent, reflect that the learner seemed to be experiencing great difficulties in allocating her attentional resources to coping with using strategies and processing listening tasks. In the third phase, listening performance generally spiraled upward to a high level, while the strategies leveled off at a relatively low level. It is necessary to point out that the beginning of the third phase in the trajectories of the two variables was still accompanied by great fluctuations. However, in the later period of the third phase, the listening strategies leveled off at a low level, while the listening performance remained at a high level.

The dynamic correlation revealed by Fig. 7 may also provide clues to resolve the ongoing debate over the effectiveness of training listening strategies. The diverging conclusions regarding the effectiveness of the listening strategy training (Cross, 2009; O’Malley, Chamot, & Walker, 1987; Ozeki, 2006; Renandya & Farrell, 2010; Seo, 2000) in previous literature may result from the fact that the data in previous studies were collected at two measurement points, pre-training or after training in particular, instead of a series of regular observations. Thus the limited observation points may overlook the hidden developmental patterns and the potential improvement along the trajectory. Particularly if the listening scores happened to be collected during the phase of fluctuations which coincided with the second phase of the present study, there may be a great chance to find that the listening strategy training did not enhance learners’ listening performance, even cause the scores to decrease. For example, Ozeki (2006) found that listening strategy training led to the decrease in students’ listening performance rather than raising their listening scores. It is possible that the students in her study may be in the stage of fluctuations and self-exploration when the listening performance was assessed. The finding may, from another angle, reflect the dynamic systems-based approaches have the advantage of examining the relationship between variables from a dynamic
perspective, as the frequent and regular observations allow us to have a relatively more comprehensive picture of the relationship between the two variables instead of the snapshot obtained by the traditional approaches.

In conjunction with the spline interpolation trajectories, we applied a moving window correlation over the study period in order to explore the correlation between the two variables. Following the phases reflected in the spline interpolation smoothed curve shown in Fig. 7, we set the window size of the moving window correlation to be ten consecutive measurement points, because it contains enough data points for reasonable estimation of the relationship. The change of the correlation of listening strategies and listening performance is presented in Fig. 8.

As can be observed, there is a surprisingly downward trend in the relationship between listening strategies and listening performance over the study period. First, the correlation coefficient started with a relatively high positive relationship in the period from week 0–18 (the first ten measurement points), then it decreased gradually to be zero in the period from week 4–22. The downward trend continued and reached a level of strong negative relationship from the period between 12 and 30 onwards.

In order to provide statistical support for the negative correlation between listening strategies and listening performance from week 22 onwards as shown in the spline interpolation trajectory and the moving window correlation, we calculated the linear regression for the two variables in this period. Fig. 9 illustrates that the listening performance showed an increasing
trend, while listening strategies showed a decreasing trend, which corresponds with a negative correlation from week 22 onwards. Therefore, the result of the linear regression corroborates the negative relationship between the use of listening strategies and listening performance from week 22 onwards.

The positive correlation between the listening strategies and performance in the initial stage indicates that listening strategies played an essential role in the student’s listening performance. Listening strategies could develop self-regulated learning habits (Vandergrift & Goh, 2012) and help users to become more competent in processing the upcoming information. Specifically, metacognitive strategies equip students with the skills needed in organizing the listening activity, such as self-evaluating listening process and selecting appropriate strategies, thus enabling learners to pay more attention to the listening tasks. In that sense, it is useful for students with relatively low and intermediate listening proficiency to “orchestrate the cognitive process more efficiently and effectively” (Vandergrift & Goh, 2012, p.43) and actively engage themselves in capturing the upcoming audio information. Likewise, cognitive listening strategies could equip students with effective techniques, such as predicting, inferring and taking note, in dealing with the listening tasks. The social/affective strategies could improve the learner’s affective and communication ability needed in carrying out the listening tasks. Given that the listening activity is generally regarded as an elusive process, it may be necessary to equip students with a toolkit composed of strategies for the purpose of enhancing listeners’ competence and tuning into a favourable affective state to processing listening tasks. Overall, listening strategies could provide students with the appropriate and efficient methods to “orient themselves to the listening task, access their background knowledge, and compare their interpretation of the input with the actual input” (Berne, 2004, p.522), thereby enhancing their active engagement and competence in processing the upcoming audio information flow.

4. Conclusion

The study investigated the dynamic patterns of listening strategy use and listening performance and explored the interaction of the two variables from a DST perspective. The developmental trajectories reveal that both the listening strategies and listening performance demonstrated non-linear developmental patterns. The moving min–max graph, spline interpolation trajectories and moving window correlation show that the student’s listening strategies and listening performance mainly underwent three seemingly co-occurring phases. As shown by the analysis, prior knowledge was found to play a critical role in the acquisition of listening strategies. The developmental path of listening strategies revealed a simplification, self-adaptation and self-organization process in acquiring and using listening strategies. The listening performance development suggests that intense fluctuations and great variability tended to occur in the proximity of a phase transition, and the regression could predict progress to some extent. It was also found that the correlation between listening strategies and listening performance is characterized by dynamic and varied developmental patterns, and the moving window correlation shows a surprisingly downward trend in the relationship between listening strategies and listening performance over the study period.

This study contributes to our theoretical and methodological knowledge of listening strategy research from a dynamic systems perspective. The findings enrich our understandings of the developmental patterns of listening strategies and listening performance, and the dynamic interaction between listening strategies and listening performance, thus revealing the advantage of the dynamic systems-based approaches in listening strategy research. This study also contributes to resolving the ongoing debate over the effectiveness of training listening strategies and allows us to have a more comprehensive picture of the relationship between the two variables. Pedagogically, the results may provide some guidance for English listening course designers in developing curriculum, syllabus and textbooks. It is also hoped that the results may be useful for practitioners to take a dynamic and formative perspective in teaching and assessing students’ listening performance, incorporate the dynamic developmental characteristics into the listening strategy training practice, and adjust the teaching practices, materials and assignments to cater for students’ developmental learning characteristics and requirements.

It is necessary to point out that this study was conducted in a short period and focused on one highly-motivated student. Considering that different learners may vary in the way that they approach listening (Larsen-Freeman, 2009) and how their strategy use develops (Graham et al., 2008), we would need to be cautious in generalising the findings of this study to the development of English listening strategy and listening performance of other learners. It may also be of interest to further testify whether the developmental patterns in listening strategies and listening performance could represent learners with particular learning styles. Follow-up studies will also benefit from employing diverse research methods, such as grid method and short-term changes to explore learners’ listening strategies and listening performance development. Following De Bot et al.’s (2007) suggestion on a holistic view of the DST approach, it would be of great interest to explore the dynamic trajectory and variation of strategy use and performance with other variables from a diverse, dynamic and holistic perspective.

Acknowledgments

I am grateful to the editor and the three anonymous reviewers for their in-depth analysis of this article and their insightful comments and suggestions. I am thankful to Prof. Diane Larsen-Freeman for her thought-provoking discussion and suggestion in applying Complex Dynamic Systems Theory in the study. I am also grateful to Prof. Martin Bygate for his encouragement and support in carrying out the study. I am deeply indebted to Dr. Shaofeng Li for his insightful comments,
Appendix A. Supplementary data

Supplementary data related to this chapter can be found at http://dx.doi.org/10.1016/j.system.2016.10.004.

References


