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A Dynamic Perspective

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Input Outside the Classroom and Vocabulary Development: A Dynamic Perspective

Abstract
Input outside the classroom, facilitated by the Internet, smart phone, and computer, has gained importance in language learning. These channels create exposure opportunities for learners of English and thereby enable language development independent of time and place. The current longitudinal study describes how the vocabulary size of four low-proficient English learners interacts with input outside the classroom, based on a time series of writing products. We have explored the vocabulary development and have used a dynamic mathematical model to explicitly investigate the dynamically interacting factors shaping the process of learning. With a dynamic perspective on vocabulary learning, our results focus on the process instead of the product of vocabulary learning. Each learner’s vocabulary learning process is regarded as a variant complex system that is interacting with other systems and that is variably dependent on input outside the classroom.

Introduction
Within the focus population of the study we are reporting on in this paper, learners of English in a Chinese L1 context in Taiwan, input outside the classroom has become increasingly pervasive in recent years. Most learners in Taiwan have full access to the English input, including movies, songs, magazines, social networks, and online games from the internet through computers, iPads, and smart phones. These channels increase the chances of learners to keep contact with English and give learners the opportunity to use English. Learners can watch English episodes, listen to English radio, read online news, play online games, and chat on Facebook whenever and wherever they want. These rich and varied opportunities could potentially lead to improvement of English language proficiency beyond these learner’s in-class learning. Learners, however, may not be aware of the importance of input outside the classroom and they may overlook the opportunities provided through these channels. Although virtually every individual in Taiwan possesses either a smart phone or an iPad with free and continuous access to the Internet, few people utilize their resources to connect to English context. Most people only use these inventions as entertainment.

The importance of input outside the classroom is shown in Xu’s (2010) study on how influential English context is on the retention of English by comparing the English learning result of Dutch and Chinese learners. Dutch learners, having lots of English input in everyday life, have a high retention of English, while Chinese learners, who have limited
access to English, do not. This finding reflects what has long been emphasized by Ellis (2002) and again by Larsen-Freeman (2002). The frequency of occurrence, as an operationalization of input, provides a key to language acquisition, especially for productive skills such as speaking and writing in English. The ability to fluently operate in English can be seen as a cumulative effect of the interaction with an authentic English environment. The more learners connect themselves with a naturalistic English context (environment), the more likely they are to develop a good command of English. Learners are not able to learn a language in isolation without interacting with the English context. Technology tools create an opportunity to integrate learners into an English context “in every classroom, on every desk, in every bag” (Bax, 2003) and may provide English learners with massive input, which cannot be achieved by limited hours of in-class English lessons per week. With increased amounts of contact time with English through various channels outside the classroom, learners enlarge the possibility of learning English better.

A quantitative study in the Netherlands (De Bot, De Quay-Peeters & Evers, 2003) intended to elucidate the factors that determine the English proficiency of thirteen to sixteen-year old lower secondary pupils. About 1574 pupils were tested on four skills of English proficiency, listening ability, reading ability, speaking ability, and writing ability. The analyses showed that school based teaching had little effect on English acquisition while the media (TV, music, computers, and internet) played an important role. Listening to pop songs, especially with comprehension of lyrics, had strong effects on listening comprehension score. Watching TV programs, with the exposure to English subtitles or spoken English, also has an impact on language proficiency, especially for listening. However, the explanatory power of the factors, listening to pop songs or watching TV programs, is very limited. Such a large-scale quantitative study could not have a full grip of what really occurred in language learning. A more detailed study is needed in which different variables determining the English proficiency are followed intensively. It is not feasible to carry out such study with thousands of subjects. Research with a dynamic approach to language on smaller scale studies, for the moment, can thus give insight into the real-time process of language learning influenced by input outside the classroom.

For the current study, we have longitudinally analyzed a time series of fifty-six free writing products of four Taiwanese learners of English for five months. Instead of merely looking at the writings before and after having input outside the classroom, the whole series of writings is monitored to gain insight into the individual learning processes. The learners kept a log of the type of English input they encountered such as English movies, songs, social network, magazines, online news and the number of hours they kept contact with these types of English input. The fifty-six writings were analyzed as an indication of their vocabulary development. To quantify vocabulary knowledge, we have used V_size v2.0 (Meara & Miralpeix, 2004) to estimate the productive vocabulary size based on the writings. The productive vocabulary size estimates how many words English learners are
able to use in English. Through mean comparison and model construction, we investigated how learners respond to input outside the classroom in terms of vocabulary size. The goal of this study was to thoroughly investigate the process of vocabulary learning of four learners in response to varying amounts of input outside the classroom.

The paper begins with a general review of vocabulary learning work and the difference between our study and the previous work, followed by a focus on vocabulary learning from a dynamic systems theory perspective. The description of data collection combines detailed learning logs with the time series of written language. The analyses and results pertaining to the concepts of dynamic system theory lead to the discussion and conclusions about the influence of input outside the classroom, as approached from a from a dynamic systems way of investigating data.

**Background**

Vocabulary learning has been a hot issue in language learning, and it also plays an essential role in language acquisition. In an influential model of language production, Levelt’s model (1989), takes the lexicon as one of the core components when producing language. Learners need around 8000 to 9000 word families (stimulate, stimulated, stimulating, stimulates are counted as one family), and about 98% coverage to be able to read authentic texts such as novels or newspapers (Nation, 2006), based on British National Corpus data. They need about 90% coverage of vocabulary to sufficiently understand the spoken discourse (Laufer, 1989). Learners must hold a large number of lexical items to be able to use English. The vocabulary size can be an important indicator of language learning.

The use of Lexical Frequency Profiles (LFP), developed by Laufer and Nation in 1995, is an approach to estimating productive vocabulary size for texts. LFP generates a profile of the given text that describes the lexical content of the text in terms of frequency bands. LFP calculates the percentage of the lexical items in the most frequent 1000 words of English, in the 2nd 1000 most frequent words, in the 3rd most frequent words and so on. The use of the percentage of the frequency bands characterizes the text in a standard way. LFP, however, as argued by Meara (2005), may not be able to detect small differences within a limited number of lexical items. That is, we may not find a different percentage of lexical items in frequency bands between a learner with 2000 vocabulary size and a learner with 2500 vocabulary size. Our longitudinal study of free writing productions, based on about two to three observations per week may not generate a significant improvement percentage in the profile.

V_Size (Meara & Miralpeix, 2004), an approach to assessing the productive vocabulary size, is an alternative way to shape the text profile directly. It gives an indication about the productive vocabulary size of the subjects who produced the text. We could make a statement that the text may be generated by a person with around 3000 productive vocabulary size. The program utilizes the Zipf’s law (Zipf, 1935) to construct the estimation
of vocabulary size. Zipf argued that the frequency of occurrence of the lexical item is inversely related to the rank of the lexical item. The most frequently occurring lexical item would be in the first rank of the lexicon. V_Size assumes that a learner with smaller vocabulary size will use more very frequent lexical items while a learner with larger vocabulary size will use more very infrequent lexical items. Zipf’s law allows us to explore the characteristic of the text produced by subjects of different levels of vocabulary size. Fifty-six free writing productions were processed with the V_size program so as to obtain learners’ approximate productive vocabulary size.

Other than vocabulary size research, many vocabulary learning studies have focused on vocabulary learning approaches. Vocabulary learning can occur through engaging learners with words more frequently. Hulstijn and Laufer (2001) compared the short-term and long-term receptive vocabulary retention between three levels of involvement loads (reading comprehension, comprehension plus filling in target words, and composition-writing with target words) and found that words which were processed with composition-writing would be retained more than words which were processed with comprehension and comprehension plus filling in target words. This engagement can make learning occur intentionally and incidentally. Knight (1994) found that intermediate-level foreign language learners (Spanish) would increase English vocabulary through reading by looking up words in the dictionary and through reading with guessing. Schmitt (2008) summarized a wide variety of activities which increase learners’ engagement in vocabulary learning, internet chat program with negotiated interaction (Smith, 2004), opportunities of generating new word forms during vocabulary learning activity (Barcroft, 2007), retelling the story by using previously shown words in a reading text (Joe, 1998), and incorporating previewed target words on notebook in classroom activities (Walters & Bozkurt, 2009). The above studies emphasize the investigation of what type of “input” learners are exposed to “in class” and from that, what type of “output” learners are expected to produce. They overlook the impact “input” outside the structured setting may bring about, however.

Vocabulary learning occurs intentionally and incidentally, in class and outside the class. When learners encounter language from various resources outside the structured setting (TV program, social network, radio, movie, online game), vocabulary learning takes place. One pitfall in the studies mentioned above is that the input outside the structured setting with engagement with the environment has not been worked out. Input from the environment has increased dramatically in recent years due to the use of computer, smartphone, internet, and media. Learners are not limited to only learning in a classroom but able to have language contact outside the classroom. This rich environment favors vocabulary learning by giving learners more opportunities to receptively read or hear the words or to productively write or speak the words, which yields higher possibility for the retention of the words. The purpose of our study is to investigate the input outside the structured setting in terms of vocabulary size.
Another pitfall from the above studies is that they only had the observation of the outcome of vocabulary learning (total number of words gained or retained after a given input) and the significance between control and experimental group. The conclusions drawn from these observations cannot tell much about how learners develop their vocabulary size over time and what other variables might have an effect on vocabulary development. Vocabulary learning should not only be taken merely as an “input-output” task (information processing), because language processing is not static but a constantly changing system. We see how learners develop their vocabulary size over time and how input outside the classroom influences vocabulary size over time.

With a dynamic perspective towards vocabulary development, we consider each individual learner as a complex system. This constantly-changing system has a set of variables that interact over time. Variables, in our study, are restricted to input outside the classroom and vocabulary development. The basic assumption is that with more contact with English context, learners may increase their vocabulary size over time, while with less input outside the classroom, learners’ vocabulary size may not grow. The input, which is regarded as an external resource to the developing system, interacts with vocabulary development over time. This takes place between, but also within individuals. In language processing the previous output can become the current input. The constantly changing, interacting, and self-organizing complex system of each individual is an essential characteristic of Dynamic System Theory (DST).

The application of DST to the theory of second language development, includes several basic characteristics (De Bot & Larsen-Freeman, 2011). The dynamic system has sensitive dependence on initial states. It features a nonlinear development with interconnected variables. The variables change through internal reorganization and interaction with the environment. “Dynamic”, in fact, refers to “the changes that a system undergoes” thanks to “internal forces” and to “energy from outside itself” (De Bot & Larsen-Freeman, 2011). DST has been applied to first and second language learning (Larsen-Freeman & Cameron, 2008; Van Geert & Steenbeek, 2005) and human cognitive system (Elman, 2004; Spivey, 2007). Our study, with a DST perspective, intends to depict the tendencies, the patterns, and the contingencies of individual vocabulary development. In addition, it attempts to reveal the relative importance of the interconnected variables, input outside the classroom and vocabulary development. We will describe the system, its constituents, its contingencies, and its interactions by dynamizing the vocabulary learning process in relation to input outside the classroom.

Meaningful interpretations of dynamic interactions will enable us to understand the developmental process of language learning. One way of doing this is by building a mathematical model that reflects the dynamic relationships between the variables that shape the system Though it is not necessary to build a model to make the system meaningful, a mathematical model gives more insight in the process by quantifying the dynamic
relationships. Observing the developmental patterns of the learning trajectories in the data will help us determine which mathematical model we should choose to describe the data of vocabulary development most accurately. At the same time, models will have to be informed by the theoretical background provided by earlier group studies, to construct the conceptual relationships of the model and to strengthen our choice of the model. Once we have determined which mathematical model could fit the data or the data with variability removed (smoothed data), we can adjust the values of parameters of the mathematical model to find the best fit between the data and the model. The values of parameters which generate the best match with the model are the most ideal ones to explain the development.

Vocabulary development, a dynamic nonlinear process, should be modeled based on dynamic iterations. The vocabulary development changes with the time, the core of the dynamic system theory. Each data point depends on the previous data point, which reveals that the process of variable unfolds step by step, the iterativity of the dynamic system. The model trend line should entail the essence of non-linearity. Non-linearity results from limited resources of the system. Without limited resources of the system, the development is linear, it increases to infinity. Vocabulary learning, in fact, is limited by the internal and external resources. Learners may lose motivation to keep learning or may lack sufficient input to maintain the vocabulary size. The logistic model, empirically and theoretically, is an ideal choice of modeling vocabulary development.

The logistic model was originally used to describe the population growth over time by Verhulst (1845). The population varying with the time can be described as:

$$\frac{dP}{dt} = rP\left(1-P/K\right)$$

Equation 1. Population logistic model equation

This equation shows the elements of the logistic model. The left part of the equation shows that the population (P) changes with the time (t). The right part of the equation shows that the growth rate of the population (r) changes with the time and the population (P) is limited by its resources (K).

The logistic model is an ideal model for modeling vocabulary development. The logistic curve is a typical learning curve that can be applied most types of development. The pattern of the logistic model is similar to that of vocabulary development. The development is slow in the initial state, is faster in the middle state, and is slow again in the final state as demonstrated in graph 1. The S curve is the pattern of the logistic model. This pattern will change with the initial value (the beginning value of the development), the learning rate (the slope of the development), and the carrying capacity (the maximum final value of the development). If we change the value of the carrying capacity (K) from 1 to 1.5 holding other parameters constant, we find the difference between the black and the red lines. If we change the value of learning rate from 1 to 2 holding other parameters constant, we find the difference between black and blue lines. If we change the initial value (the beginning value
of the development) from 0.12 to 0.15 holding other parameters constant, we find the
difference between black and green lines.

Previous applications of logistic model modeling have shed important light on the
dynamic interactions of components of dynamic systems. Caspi (2010) utilized the logistic
model to study four English advanced learners on their academic word learning. She found
that the gap existed between different levels of vocabulary knowledge, the more receptive
vocabulary knowledge acted as conditional precursors for more-productive vocabulary
knowledge, and the supportive or competitive relationship between more receptive
vocabulary knowledge and more productive knowledge. Chan and Lowie (2010) utilized the
logistic model to evaluate three levels of vocabulary knowledge development of four
English learners with the assistance of a computer program. In both studies, the logistic
model successfully interprets different levels of vocabulary knowledge development, along
with the parameters (initial value, learning rate and carrying capacity). Our study uses the
logistic model to describe four learners’ vocabulary size development in response to input
outside the classroom.

Method
We followed four learners of English for five months by collecting fifty-six writings. They
were exposed to input outside the classroom with different volume in different stages.
Based on the log they kept everyday, we could divide their input stages into three and four.
Skid, with three stages, was from low input stage, medium input stage with movie, to
medium input stage with reading. Tina, Grace, and Gloria, with four stages, were from low
input stage, medium input stage, high input stage, to medium input stage. Through a mean
comparison and model construction, we found how individual learners responded to input
outside the classroom in terms of their productive vocabulary size.

1. Participants
Four Taiwanese native speakers of Chinese and learners of English, participated in the
study. Their general English vocabulary size, estimated by the English test “General English
Proficiency Test” in Taiwan, was at least 2260 words. They had learned English for
approximately ten years. Skid, a male senior engineer, started his English learning from age
thirteen. Tina, Grace, and Gloria, all 16-year old teenage girls, are very close to each other.
They all started to learn English at age five. As far as sub-skills were concerned, based on
the interview of the subjects’ English teacher and their English assessments, Skid could read
well but could not comprehend fast-paced English conversation. Neither could he speak
fluently and smoothly nor write with appropriate grammar structure. Tina held equal levels
of English listening, speaking, reading, and writing, but she was particularly good at
speaking fluently and bad at writing grammatically-correct sentences. Gloria and Grace held
similar levels of four perspectives of English ability, but Gloria was particularly good at
writing grammatically-correct sentences and using appropriate words in the context, and Grace was particularly good at reading long texts.

2. Materials

Participants were given half part of the English input from the researcher, but were able to choose another half part of the English input. They decided when and where they wished to have English input and kept a log of the input they received. There are several English input resources participants have access to, namely songs, movies, and online news, but they seldom made good use of any of them. The three teenage girls, with four input stages, had similar quantity and type of English input in different states, while Skid, with three input stages, had a bit slightly different quantity in different stages.

The input stages for Skid were from low input to medium input with movie, to medium input with reading. Skid did not have any English input from writing 1 to writing 19 (low input stage). He only practiced writing the given topic and received only content feedback from the researcher. Skid, in stage two (medium input), started to have regular online chat twice a week for one hour and watch movie trailers as English input from writing 20 to writing 38. In state three (medium input), Skid kept the regular online chat but read three online articles about news instead of movie trailers from writing 39 to writing 56.

The input stages for Tina, Grace, and Gloria started at low input, followed by medium input, high input and back to medium input. Tina, Grace, and Gloria had similar English input, because they are close friends. They always enjoyed listening to English songs and singing English songs. In state one (low input), they had only songs for English input from writing 1 to writing 10. They posted their writings on the “writing club” on Facebook and sometimes gave feedback to others’ writings. In state two (medium input), from writing 11 to writing 20, they added some English input by reading online articles about news. In state three (high input), from writing 21 to writing 37, they not only read online articles everyday but also watched two to three English movies a week, frequently chatted with friends on Facebook or in person in English, kept their habit of singing English songs as well. In state four (medium input), from writing 38 to writing 56, they read two or three online articles per week, watched one English movie per week, but did not have much chat with friends in person or on Facebook.

3. Data Collection Procedure

All participants wrote three 200-word writings per week during five months and sent to researcher’s mail box or posted on Facebook each time they completed one. A “Writing club”, constructed on Facebook for learners, made it easier for learners themselves to read each other’s compositions and to comment on what they read or wrote. After receiving the feedback from the researcher, mostly content feedback, they could freely choose to respond or not. There was no requirement to correct their grammatical or lexical errors. All writings were transformed into text files, for we could utilize V_size v2.0 (Meara & Miralpeix,
2004) to estimate the vocabulary size from the writings. Errors like wrongly spelt words were excluded from the text. Proper names, like Taiwan and Japan, are recoded as highest frequency band to avoid the overestimation of the productive vocabulary size. Hyphenated words, like well-known, are counted as two words in V_size, so we edit them to one word, like well-known. We obtained the estimated vocabulary size using V_size and registered longitudinally how vocabulary size develops at the three (Skid) or the four (Tina, Grace, and Gloria) degrees of intensity of English input.

4. Analysis

To investigate how the vocabulary size of four English learners is developed in response to their English input, observations of the graph of raw data pertaining to different English input stage are traced out. To describe the vocabulary development of four learners, building up mathematical models which maximize the likelihood of reflecting the empirical data.

Results

1. At a First Glance

We demonstrate the vocabulary size changes, as determined by the V_size tool, pertaining to different period of input in figure 1 and 2 (raw data and mean) and in Table 1 and 2.

<table>
<thead>
<tr>
<th></th>
<th>Stage 1 1-19 Low input</th>
<th>Stage 2 20-38 Medium input with movie</th>
<th>Stage 3 39-56 Medium input with reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skid</td>
<td>4415</td>
<td>5884</td>
<td>4905</td>
</tr>
</tbody>
</table>

Table 1. Vocabulary size and Stage sequence for Skid

<table>
<thead>
<tr>
<th></th>
<th>Stage 1 1-10 Low input</th>
<th>Stage 2 11-20 Medium input</th>
<th>Stage 3 21-37 High input</th>
<th>Stage 4 38-56 Medium input</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tina</td>
<td>3060 words</td>
<td>3270 words</td>
<td>4111 words</td>
<td>3652 words</td>
</tr>
<tr>
<td>Gloria</td>
<td>3620 words</td>
<td>3570 words</td>
<td>3958 words</td>
<td>3842 words</td>
</tr>
<tr>
<td>Grace</td>
<td>3030 words</td>
<td>3120 words</td>
<td>3600 words</td>
<td>3621 words</td>
</tr>
</tbody>
</table>

Table 2. Vocabulary size and Stage sequence for Tina, Gloria, and Grace.
Figure 1. Vocabulary size development of four learners

Figure 2. Mean of vocabulary size of each input stage of four learners.
Skid’s vocabulary size, even during the period of no input, still grew by reflecting and practicing the words, which he originally knew receptively but started to produce in writings. Skid was highly motivated by the input of chat and movie trailers, where his vocabulary size grew about “1469” words from the low input period to the intermediate input period. However, Skid was less motivated by the input of online articles than movie trailers, where his vocabulary size decreased by “979” words. During this period, he became a bit tired of writing with merely input from chat and online articles. However, Skid, observed from the content of his writing, used more new words learned from the chat and online articles correctly in the writing task than new words learned from the movie trailers.

During the low input period, Tina’s vocabulary size did not grow, but it increased by “210” words when receiving intermediate input and by “841” words when receiving high input. When receiving less input in the last period, she lost “459” words in vocabulary size. Tina showed that she was sensitive to the volume of input. The more volume of input she received, the more her vocabulary size increased. She liked to use new words gained from chats with friends in writings, especially more native-like chunks. Her writings reflected her preferred way of saying things and using words, because she liked to sound and speak like a native speaker.

During the low input and the intermediate input period, Gloria’s vocabulary size did not grow, but it increased by “388” words when receiving high input. She lost “116” words in vocabulary size when receiving less input in the last period. Gloria only showed a slight growth in the high input period. She was less sensitive to the volume of input, showed a stable learning curve, and used new words gained from online articles in writings carefully, especially low frequency words.

Grace’s vocabulary size, even during low input period, gradually increased, but her vocabulary growth slowed down during the following intermediate input period. Her vocabulary size increased by “480” when receiving high input and was able to retain her words in the following intermediate input period with a difference of only “21” words in vocabulary size. On the other hand, the data suggest that Grace had a delayed effect of input. Grace tended to grow, to stabilize, to grow again and to stabilize again. She liked to use the words she already knew and only started to use new words when completely knowing how to use them. This pattern may explain the trend of her vocabulary size over time.

Visual inspection of the data, the mean vocabulary size of each input stage, suggests that the vocabulary size changes are related to the different periods of input in Figure 1, in Figure 2 and in Table 1 and Table 2. The four participants all show an upward trend in their vocabulary sizes while receiving comparatively more input than in the previous stage; likewise, they tend to have a downward trend in their vocabulary size while receiving comparatively less input than in the previous stage, but the downward trend seems alleviated by the delayed learning effect of the previous state. These visual observations
lack precision and certainty, but by focusing on the individual trajectories of vocabulary we were able to quantify and model the vocabulary development, in order to gain more insight into the developmental process.

The productive vocabulary size of each learner increased by about five-hundred words in a period of five months. The time window of the observation may not have been long enough for the learners’ vocabulary size to increase to a higher extent, especially with regard to their free productive vocabulary size (as Caspi 2010 also showed). Learners may recognize new words, but may not be able to use them productively. Despite the small increases though, we were able to model their development.

2. **Modeling Vocabulary Development**

We fit our smoothed data with the logistic model and obtain the initial value, the learning rate, and the carrying capacity for four learners. Figure 3 shows the smoothed data and the fitted data. Table 3 shows the values of the parameters, initial value, learning rate, and carrying capacity. Data from Tina, Gloria and Grace showed good fitting. The smoothed data and the model were in good agreement. The logistic model could describe the vocabulary development well for these three learners. Tina had lower initial value but higher learning rate. Her development closely followed the logistic growth curve (“S curve”). Her vocabulary size increased faster when starting to have more and more input outside the classroom but started to saturate in episode 38, which was about the moment that the input outside the classroom became much less than the previous period. Tina was especially sensitive to the volume of input outside the classroom regardless of the type of input she was exposed to. Gloria and Grace, on the other hand, were less sensitive to the volume of input outside the classroom. Neither were they very sensitive to the type of input they were exposed to. Their learning rate was comparatively low. Gloria held higher initial values than Grace but held the similar learning rate as Grace. Both learners showed very similar pattern of vocabulary development.

Skid’s model showed a relatively poor fitting, as the smoothed data and the model were low in agreement. The logistic model did not only fail describe the initial state accurately; the middle state and the final state also deviated from the expected pattern of the logistic model. The model had a very high learning rate and reached its carrying capacity already at the very initial state of learning. In other words, the logistic model generally failed to reflect the reality in Skid’s data set.
### Table 3. Parameter values in the logistic model of four learners

<table>
<thead>
<tr>
<th>Name</th>
<th>Initial Value</th>
<th>Learning Rate</th>
<th>Carrying Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skid</td>
<td>4307</td>
<td>1</td>
<td>5094</td>
</tr>
<tr>
<td>Tina</td>
<td>2732</td>
<td>0.119</td>
<td>3846</td>
</tr>
<tr>
<td>Gloria</td>
<td>3531</td>
<td>0.03</td>
<td>3973</td>
</tr>
<tr>
<td>Grace</td>
<td>3070</td>
<td>0.03</td>
<td>3778</td>
</tr>
</tbody>
</table>

Figure 3. Logistic model of four learners
Discussion

The objective of this study was to find out in what way input outside the classroom influences vocabulary development. The logistic model analysis showed that the three participants in our study (Tina, Grace, and Gloria) enlarged their vocabulary size with input outside the classroom. They did not have the same initial vocabulary size but achieved a similar size of vocabulary in the final state due to different learning rates. The study showed the differences of sensitivity to input conditions between the three different learners by focusing on the learning rate. The learning rate shows the impact of input outside the classroom for the learners. Apparently, Tina was more sensitive to input outside the classroom than Grace and Gloria. Skid did perform differently from these three girls. His vocabulary development showed considerable variability. In fact, his smoothed data indicated that there may be three overlapping logistic models. A logistic model was not capable of capturing the characteristics of his vocabulary development.

The logistic model, at present, successfully quantifies the vocabulary development with initial value, learning rate and carrying capacity. These values give us explicit observations on how input outside the classroom influences vocabulary development. The model of the L2 vocabulary development presented is preliminary, as it did not yet tolerate a decrease in the development. Within the model, the learners’ vocabulary sizes can only increase to a variety of degrees in the course of development. In contrast to the model, real development of learners’ vocabulary size may decrease when learners do not have sufficient input outside the classroom, when learners do not have enough motivation, and when learners do not choose the appropriate level of input. In other words, the model has to be refined to allow for both upward and downward variability.

The variability that the data showed within each individual is huge, compared to the mean. There may be three factors causing this effect. The effect of variable input outside the classroom, the learners’ natural variability in text output, and naturally occurring variability in text type. The longer the learners write texts, the more natural is the decrease of interests and motivation, and we could expect a natural decrease by the time learners write each article. The topic of the writings also influences the output of the texts, which highly depends on personal experience and preferences. The topic of writing about the learner’s favorite singer and the topic of writing about their favorite food have shown an effect on word selection. Although this is an inherent challenge for all studies that use longitudinal approaches to writing in a natural environment, in further studies this type of variability will have to be minimized.

The vocabulary size of all learners increased by about five hundred words over five months. The time window of the observation may not be long enough for learners to show a larger growth of vocabulary size, especially for the productive vocabulary size. Learners may acquire some new words, yet may not be able to use them productively in a text. The time window of this study may not have been long enough to allow for incidental learning
by simply watching movies, listening to songs, and reading some online news. We will continue to collect the writings of these participants in an ongoing study to extend the time scale of the observations.

**Conclusion**

This study has attempted to investigate L2 lexical development in response to input outside the classroom and has used the logistic model to account for the development. The logistic model quantifies the important components of vocabulary development, the initial value, the learning rate and the carrying capacity. Observing these values, we found that these three English learners had approximately a five hundred word increase of vocabulary size over five months. Learners with more input outside the classroom, kept themselves in an English context and benefited from having more opportunities of using English.

Although this longitudinal study has collected data on a relatively short-term time scale, it has explored the microscopic level of understanding the actual lexical development on the spot and also reveals several interesting properties of DST. The iteration of the data points refers to using the output from one iteration as the input to the next. Non-linear development results from the limited internal and external resources available. Our study does not intend to criticize the current way of studying language learning, but attempts to complement it by going beyond the static way of looking at the data in an attempt to come to an understanding of the dynamics of language learning.
References


