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http://dx.doi.org/10.4314/jlt.v46i2.6

Multichronic complexity in second language development

ABSTRACT Taking a dynamic systems perspective on second language development, this paper argues that development is change over time, which is never stable and has no end state. Moreover, time can be defined at different scales: from the millisecond, minute, week and year to the lifespan. At all scales we can see change over time in language development at different levels of granularity; however, the time scale and level of granularity we use determines to a great extent what we find. What seems a change at one level may be nothing more than natural variation at another one.

Keywords: Multichronic complexity, language development, variation, time scales

1. Introduction

In his *Framework for the study of linguistics*, Weideman (2011) endorses a dynamic perspective on language learning and language development. He argues that various characteristics of dynamic systems theory are relevant for our thinking about language, especially as they may account for how language emerges both synchronically and diachronically. One of the fundamental characteristics of dynamic systems is that they develop over time and that they never reach an end state. However, as Weideman mentions, relatively stable states may occur in "maturation of language", a strong attractor in dynamic systems theory (DST) terms, or reversed states may occur in "possible loss in aphasic conditions" (135), a regression in DST terms. Even though strong attractors may occur, dynamic approaches to language hold that there is no end to development as the system will always change, constantly adapting to its use in communication. Since the communication and the context of use also keep changing the mutual adaptation will never end.

Weideman argues that in the study of language there is a manifold of factors to be considered that may play a role: "numerical, spatial kinematic, physical, organic, sensitive, logical, formative, social, economic, aesthetic, juridicial, ethical and confessional" (157). These factors constitute interacting variables that impact on language development in complex ways. An example of an interaction is the subtle differences in language use in different religious communities.

[1]The same can be said about the complex interaction between different subcomponents within the language system. What is more, the interaction between different factors will take place at different timescales, which will be the main focus of this contribution. Therefore, inter-individual variation, and intra-individual variability in all systems at all levels is the norm.

Development of different components of language can take place at different time scales that interact, a dynamic process which we will call *multichronic complexity*. We will argue that different factors play a role at different time scales and therefore also interact dynamically in the time dimension. For instance, the physical part will show change at the millisecond level or lower, while the social develops at the second and minute scale as it plays out in interaction and conversation. The economic and confessional level is likely to play a role on the week, month, year and maybe even the life span scale. In this paper, we will first briefly discuss the elusive nature of time and then give a few examples of how applying different time scales may apply to the interpretation of language development

2. Time and change

It is well beyond the scope of this article to discuss the long history of the study of time. From philosophy to astronomy, time has been the object of study in some cases with some specific sub-disciplines, such as chronobiology, where time is the explicit focus. The focus here is time scales as they are relevant to interpreting language development. Even though time is often objectified by means of metaphor in our common thinking (we have time to do things we can buy or lose time, we can spend it or spill it), time is not a thing and what it actually is, is largely a mystery. Here we will take the position that time is change. In other words, the passing of time is defined by changes, like oscillations of molecules and the hands of the clock. However, time should not be confused with circadian rhythms visible in nature: these are not apportioned by a time keeper or clock, but by the pulses generated by a special organ in the brain, the nucleus supermarignalis.

We tend to think of time scales as naturally given. While some time scales are defined by external changes, like the seasons and years, but also day and night, other timescales like months, weeks, hours, minutes and seconds are cultural inventions with no 'objective' reference. For instance, the definition of a second as ratified in 1976 is: ' the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the groundstate of the caesium-133 atom' (Guinot & Seidelmann 1988). Lombardi (2007) provides an interesting overview of the history of time scales and argues that the division of the time between sunrise and sunset into 12 hours and the year in 12 months results from the Egyptians' use of a duodecimal counting system. The 7-day week was common in Babylonia and was taken over by Judaism and Christianity following the description of the creation in the book of Genesis, but it has no natural basis. ' Unlike the day and the year, the week is an artificial rhythm that was created by human beings totally independent of any natural periodicity.' (Zerubavel 1989, 42). Minutes became units with the invention of mechanical clocks in the 16th century. There are 60 seconds in a minute for no other reason than a parallelism with 60 minutes in an hour.

1 An example is the now faded distinction in Dutch of 'op de eerste plaats' vs. 'in de eerste plaats' (in the first place) with the former used more in Catholic circles and the latter in Protestant circles.

However, no time scale is absolute: even the orbiting of the earth around the sun cannot be measured using an external standard of reference, since all reference points in the universe move themselves. This has led to the concept of dynamic time in which time is seen as relative rather than absolute. This is in line with human perception of time. In contrast to other senses (touch, smell, view) we have no special organ or mental module that perceives time as such. 'In so far as time is something different from events, we do not perceive time as such, but changes or events in time.' (Le Poidevin 2010, 1). The perception of time is to a high degree contextualized and situated: [2]minutes are rather long for holding your breath, but very short while watching a favorite movie.

3. The fractal nature of time scales

Time is fractal in nature: according to its founding father, a fractal is "a rough or fragmented geometric shape that can be split into parts, each of which is (at least approximately) a reduced-size copy of the whole," (Mandelbrot 1982, 64). This form of self-similarity can be found in nature in many forms, like cauliflowers, snowflakes and Mandelbrot's own example, the British coast. At different and sometimes all possible scales of magnitude or granularity the configuration is similar and there is no final scale on which 'the best' configuration can be found. Fractal patterns result from the complex interaction of variables. Self-similarity can be found not only in space, but also in time. The same patterns can be found on different time scales. An example can be found in the research on motivation in a foreign language classroom (Waninge 2010). Motivation has been measured on the scale of months, weeks, days and minutes. Similar patterns of variation can be found on these time scales as visualized in figure 1. What appear to be stable phases in time on one scale, or attractor states in terms of Dynamic Systems Theory, appear to show variation on a finer time scale, and that applies to all scales. Larsen-Freeman (1997) states that a similar fractal pattern can be found in the application of Zipf's law on the power relation between word frequency and its frequency ranking in texts of different lengths, ranging from large corpora to texts of only a few words. The distribution of high and low frequency words shows a power law distribution on all those scales.

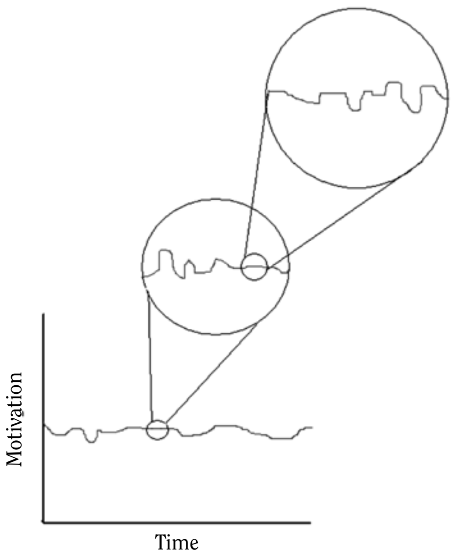

Figure 1: The fractal nature of time scales (from: Waninge 2010)

4. Time and language development

Language develops at all time scales during the human life span. Time is fractal in nature in the sense that it is scale free. This means that we can look at the year scale

[2] The relation between time and change is also visible in the etymology of the English word 'week', which derives from olf-English *wice*, ultimately from Old-Germanic*wikõn-, from a root *wik- "turn, move, change".

or millisecond scale and all scales in between, and there is no scale that is 'the' scale for language development. Through the methodology used to gather data, we define the time scale we are using. A 2-year longitudinal study with monthly observations takes place on the month time scale and the year time scale and all time scales between them (half year, 2 months and so on). A 5 minute lexical decision experiment takes place at any scale between 300 milliseconds and 5 minutes. But that doesn't mean that development takes place only at the time scale used for the measurements. Language development is in that sense also scale free, even when the focus is on one particular time scale.

An example of a definition of a time scale in research on language development can be found in the 'manual' for first language attrition research as formulated by Schmid (2004). On the basis of an overview of research in first language attrition, she argues that the preferred period of non-use, the incubation time for attrition to happen, is 10 years. Shorter periods of time may be too unstable with too much residual knowledge to measure real decline. This does not mean that after 10 years of non-use attrition suddenly sets in: attrition happens at all time scales, though not necessarily on all times scales or windows at the same rate. Attrition of syntactical knowledge appears to take years, while for phonology a few months may be enough for the replacement of mother tongue sounds by patterns from the L2. A particular problem with research on attrition is that the measurement of language skills may actually interfere with the natural process of decline: testing may lead to conscious or subconscious reactivation of skills, and in several studies (Weltens 1989, Grendel 1993) it has been shown that non use does not necessarily lead to instantaneous decline: the research findings suggest a residual learning effect even without instruction or contact.

5. Time scales and time windows in development

Timescales refer to the granularity of the developmental process: we can take a very global perspective and look at changes over the life span at many moments of time. The timescale is at the life span levels of decades, and the time window spans the whole period. Time windows refer to the period of time studied. So we can look at phonological development of learners over a period of 2 years (time window) but measure their performance every week (time scale)

There is no research that covers language development on the life-span level. No individual has been followed from crib to coffin, and as far as we know only two publications that look at language development over decades. The first is a 16 year longitudinal study by de Bot & Clyne (1994) on Dutch migrants in Australia and a study on the development of writing in a professional academic by Trinh (2011) that will be discussed in more detail later on.

The study on Dutch migrants in Australia looked at migrants that had arrived in the 1950s and that had been interviewed and tested by Michael Clyne in the late 1960s and early 1970s. The same people have been interviewed and tested again in 1987, and the results showed that there was some decline in language proficiency. The participants appeared to have maintained their 1950s' ways of speaking, augmented with phrases from recent broadcasts of popular sitcoms from Dutch televisions. In 2005 Clyne arranged another retesting of a part of the same group and found that many of them had retired in a mainly Dutch spoken ethnic retirement village and that their Dutch had actually improved (Clyne, personal communication)[3]. So to what extent attrition or relearning can be evidenced depends on both the time scale and the time window of measurement. It is quite likely that on the decades life span there is a gradual decline, but that on a smaller scale, the general pattern has been modified due to more contact with Dutch through the media and more visits to the Netherlands. Retirement in a overwhelmingly Dutch spoken environment is likely to be a major linguistic life event that had an impact on skills.

6. Recent research on language development on different timescales

Inspired by a DST framework in which time is seen as change with fractal properties, we have also become interested in the implications of different time scales in our own research. In recent years, two projects have been set up at the Department of Applied Linguistics of the University of Groningen that focused on language development at different time scales. The first is a 3 year longitudinal case study with reaction time data and the second is the previously mentioned study of academic writing development.

In the longitudinal study of word naming latencies in L1 and L2, reported on in more detail in de Bot & Lowie (2010) and Plat (2010), the aim was to find out whether representations of words in the bilingual lexicon, as measured by latencies in a word naming task, were stable over time. In a single subject 3-year longitudinal study a Dutch native speaker with advanced proficiency in English performed a word naming task in Dutch and English. Conditions were kept as similar as possible: The test items had been pretested so that inter-item variability was limited as much as possible and only those items showing little variation between and within subjects were included in the study. There were 200 items in both the Dutch and the English pair of the experiment. The items were always presented in the same order and the Dutch part always preceded the English part. The participant was tested twice on testing days, in the morning between 9 and 10 AM and in the late afternoon between 5 and 6 PM. The experiment was administered twice a year over a 36 month period, so there were 4 data sets each year. Here we will report on some of the findings from the first 5 half-year testing intervals. The data of this study allow us to look at development and variation on time scales ranging from milliseconds to years. Figure 2 shows the pattern of reaction times over a single 200 word session in Dutch.

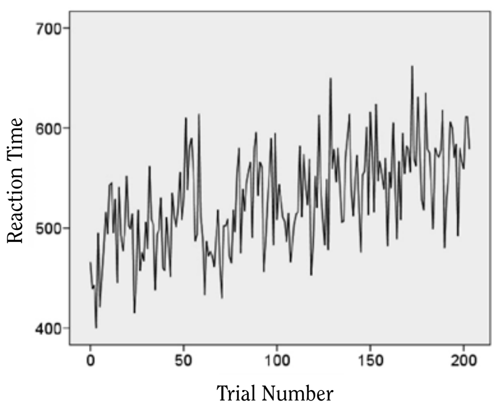

Figure 2: Reaction time data English naming task single session (de Bot & Lowie 2010, Plat 2011)

These data show that there is considerable variation in RTs, which is remarkable because the items had been selected in such a way that they showed as little variation as possible in pretests. There is a gradual increase in latencies over the course of the test session, probably reflecting a decline of attention. When the data from the series of

[3] Sadly, Michael Clyne passed away in 2010 before he could formally report on these findings.

sessions in the two languages are chained in one series of reaction times, fractal patterns can be detected at different time scales (Plat in prep.)

When zooming in on the millisecond time scale, we find variability that cannot be explained, despite the fact that the selection of items made use of very strict initial criteria and was subsequently pretested with the goal to keep variation between items to an absolute minimum. Nevertheless, the amount of variation found within the individual items is considerable. Generally, the standard deviations in the English test were larger than the standard deviations in the Dutch test. The mean RTs over sessions clearly also showed that the variation in response times could not be caused by item-specific characteristics. Moreover, partial data analyses showed that this result could not be accounted for by periods of decreased concentration. The only conclusion that can logically be drawn from this is that the activation of individual lexical representations is quite variable and not stable over time.

The data presented in figure 3 show average reaction times on 5 days, morning and afternoon, over about a half year period, so a total of two and a half year. The .1 data are from the morning sessions, that .2 data from the afternoon sessions. The data clearly show that reaction times are slower in the afternoon than in the morning, which may be related to the subject's chronotype and circadian rhythm (de Bot 2012): apparently the processing system is more effective in the mornings than in the afternoons.

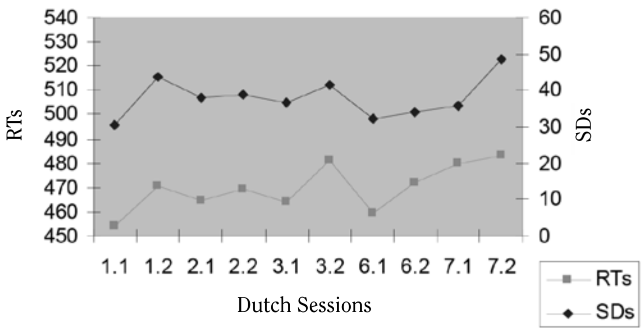

Figure 3: Reaction time data Dutch naming task over 10 sessions (de Bot & Lowie 2010, Plat 2010)[4]

The data from this longitudinal case study also allow us to look at development at different time scales. Though there is a 25-millisecond difference between session 1.1 and session 7.2, the outcomes show that the variation and change over time is fairly limited. In other words, while there may be change during sessions on the millisecond and minute scale and the day-scale as reflected in the morning and afternoon data, there doesn't seem to be much change at the month and year scale. However, as Plat (2010) has shown in a spectral analysis of the reaction time data, the means over sessions are only part of the story: the distribution of the reaction time differences over time may reflect differences in processing, which may be related to more or less automaticity and control. The spectral analyses are somewhat complex and a full treatment is beyond the scope of the present contribution, but in short a pattern of highly similar reaction times suggest more automaticity while a more varied patterns suggest more strategic, controlled behavior. Looking at the data at different time scales we see unexplained variation at all scales, a finding in line with general DST principles.

[4] Here we report on the measurements every half year. In fact there were in-between measurements (41/4.2/5.1/5.2) that are not reported on here.

The second project looked at the development of lexical and syntactic complexity over time in an expert academic writer. For this excerpts from scholarly publications of this writer over a period of 37 years have been analyzed. (For details on the analysis, see Trinh 2011). Figure 3 presents the data on lexical complexity defined by a combination of mean word length and type-token ratio with the yearly data points and the polynomial representing the trend line.

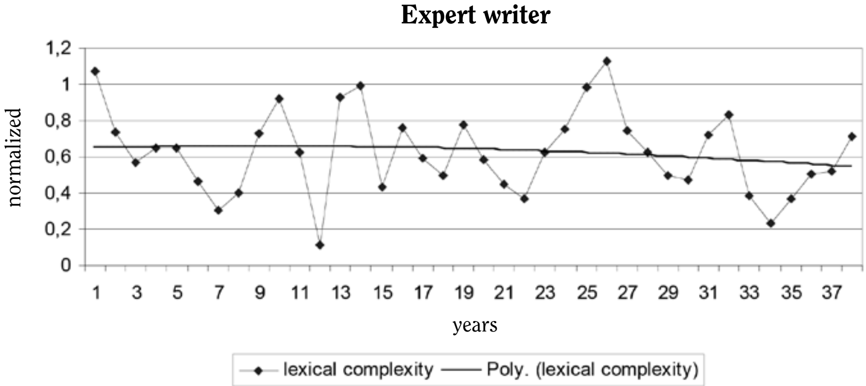

Figure 4: The development of lexical complexity over time (Thahn 2011)

These data show how the selection of time scales and time windows can lead to different conclusions: e.g. had the window of analysis been year 1-12, the conclusion would be that there is clearly a decline of lexical complexity over time, suggestion attrition on this level. Similarly, a comparison of year 12 and 27 clearly shows a growth in complexity. An analysis on a smaller scale within the same window, e.g. every five years, would lead to the conclusion that there is no real change, and this is also what the trend line suggests.

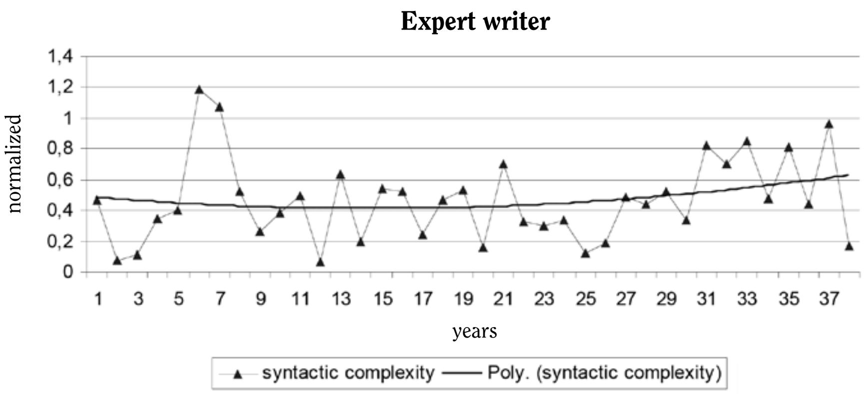

Figure 5: The development of syntactic complexity (Thahn 2011)

The data on syntactic complexity show that there is less variation apart from the peak in years 6 and 7. Trinh's analyses show that there seems to be an inverse relationship between lexical and syntactic development, when one grows, the other declines. An analysis at finer time scales might inform us about what causes the variation in the development. It may be that the writer at some point begins to work on a new topic and therefore uses 'new', less frequent words but that over time she finds ways to get her ideas across in simpler terms. Again this study shows that unexplained variation is the norm and that if we look at change over time, our time scale may very much determine what we find.

7. Conclusion

For the study of language development time is the essence. The DST perspective we take as a starting point in our study of language and other higher cognitive functions focuses on change over time. Essentially no open system is ever static. While this is in fact a truism, in the study of SLD, and in particular in the branch that takes Universal Grammar as its starting point, the notion of an 'end-state' in development was generally accepted (see for a discussion de Bot, Lowie, Thorne & Verspoor (2012)). The data presented here make it clear that there is no end state, not for simple and frequently repeated tasks like a work naming task, nor for highly skilled language users like de expert writer discussed above.

Language development is a complex process that takes place on many interacting time scales and the time scale chosen will have an impact on the selection and interpretation of the data. The same holds for the time window used. There is no time scale or window that gives a full picture of the total process of development. Development on one scale is influenced by what happens on smaller and larger scales and development at these levels will have an impact on what happens on the time scale in focus. Just like the shape of the British coast depends on the measuring scale chosen, so the shape of language development depends on the scale at which the analysis aims at. Of course, it is impossible to measure development of all levels of granularity and that could lead to a defeatist view: if you cannot measure at all scales, but they all do play a role in development, how can you study development to start with? This may be taking the argument too far. It continues to be valid to study lexical development over a few months, but care has to be taken not to over interpret the findings: what is seen in terms of change will be the results of developmental processes on different scales and not just on the one the methodology used provides data on.

The notion of interacting time scales necessitates a review of a large part of the research on language development. What is interpreted as an increase on one time scale, may actually be part of a decrease on another scale. Changes on different time scales may be in the same direction or in a different one, so stability (or maturation) may in fact be the resultant of processes of growth and decline on different time scales. Therefore, we argue that the study of language development should be done longitudinally with data at different levels of granularity and that we need to combine data from different timescales to get a fuller understanding of the larger process. Here we have touched only on sub-systems of the language system and a limited number of timescales. The myriad of potential factors Weideman (2011) mentions and the timescales at which they operate are still waiting to be explored; though their relevance is beyond doubt.

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