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## Learner Variability and Student Modeling

This paper reports on a relatively new project. The goal of this project is to model the interlanguage processes of language learners in a CALL environment and to capture this complex, dynamic network of variables in a student model. Relying on research in interlanguage theory (Gass & Selinker, 2001; Selinker, 1992) and learner language analysis (Granger, 2003; Granger & Petch-Tyson, 2003; Heift & Schulze, 2007), we empirically analyse texts produced by students of German to create individual student profiles that focus on mastery/non-mastery/avoidance of language structures over time. Moreover, learner variables such as native language, age and language proficiency which have a known effect on the interlanguage process will be considered. We will examine these plots of individual learning processes using the general approach, the underling philosophy, and selected mathematical algorithms from chaos theory (Dewaele, 2002; Larsen-Freeman, 1997; Williams, 1997).

Student models are more complex than other user models because misconceptions and inconsistencies in the student's knowledge have to be considered. Mitrovic et al. (1996) identify four different sources of this noise: inconsistent student behaviour, dynamic and nonmonotonic nature of human learning, ambiguity of possible explanations for the observed behaviour and indeterminacy of student answers. Certain aspects of observable student behaviour can only be described as stochastic.

This is the reason why we base our data analysis on current discussions of dynamic systems theory (e.g., Katok & Hasselblatt, 1997) and chaos theory (Williams, 1997) within second language acquisition theories (de Bot, Verspoor, & Lowie, 2005; Herdina & Jessner, 2002; Larsen-Freeman, 1997, 2003) and e.g. education (e.g., Haggis, 2005). A chaos theoretical understanding of language learning processes has some clear methodological advantages to our project. We need a sufficiently formal approach to processing large, complex data in investigating individual processes and outcomes because we must pay close attention to a variety of possibly interrelated and interdependent variables. Moreover, these variables change over time. This makes established algorithms from chaos theory and dynamic systems theory most appropriate.

Along the lines of Larsen-Freeman (1997), we also believe that chaos theory can help us to find a number of answers to as yet unanswered questions in second language acquisition. Like Larsen-Freeman (1997), we view language learning as a dynamic, complex and nonlinear process. Dynamic refers to the process of synchronic use, the process of diachronic change, and the fact that language use and language change are intrinsically linked. We assume that it might be more fruitful to try to predict the next phase of the complex system's change and not some stage at which the system might come to a rest. We can establish what the system (in our case foreign language learning) will not look like, we can reason what the most likely state is in which the system will find itself, but we cannot tell exactly where the system will be ('strange attractor'). Often it will only be possible to describe the path a system took to a particular state after the fact. This is the main reason why we use existing student data in the early phases of our analysis for modeling the student data from online German courses. These data consist mainly of student writings and tracking data.

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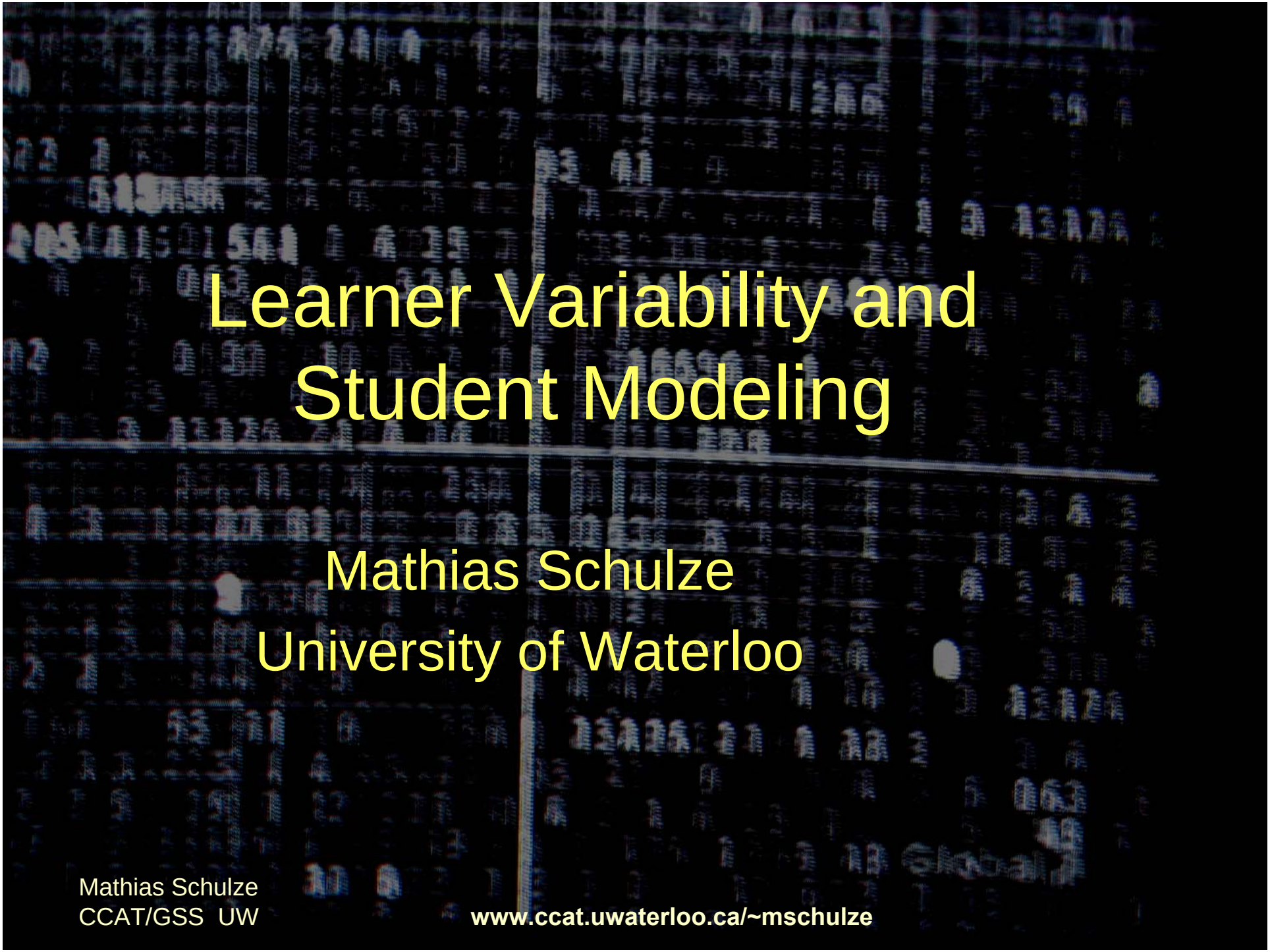

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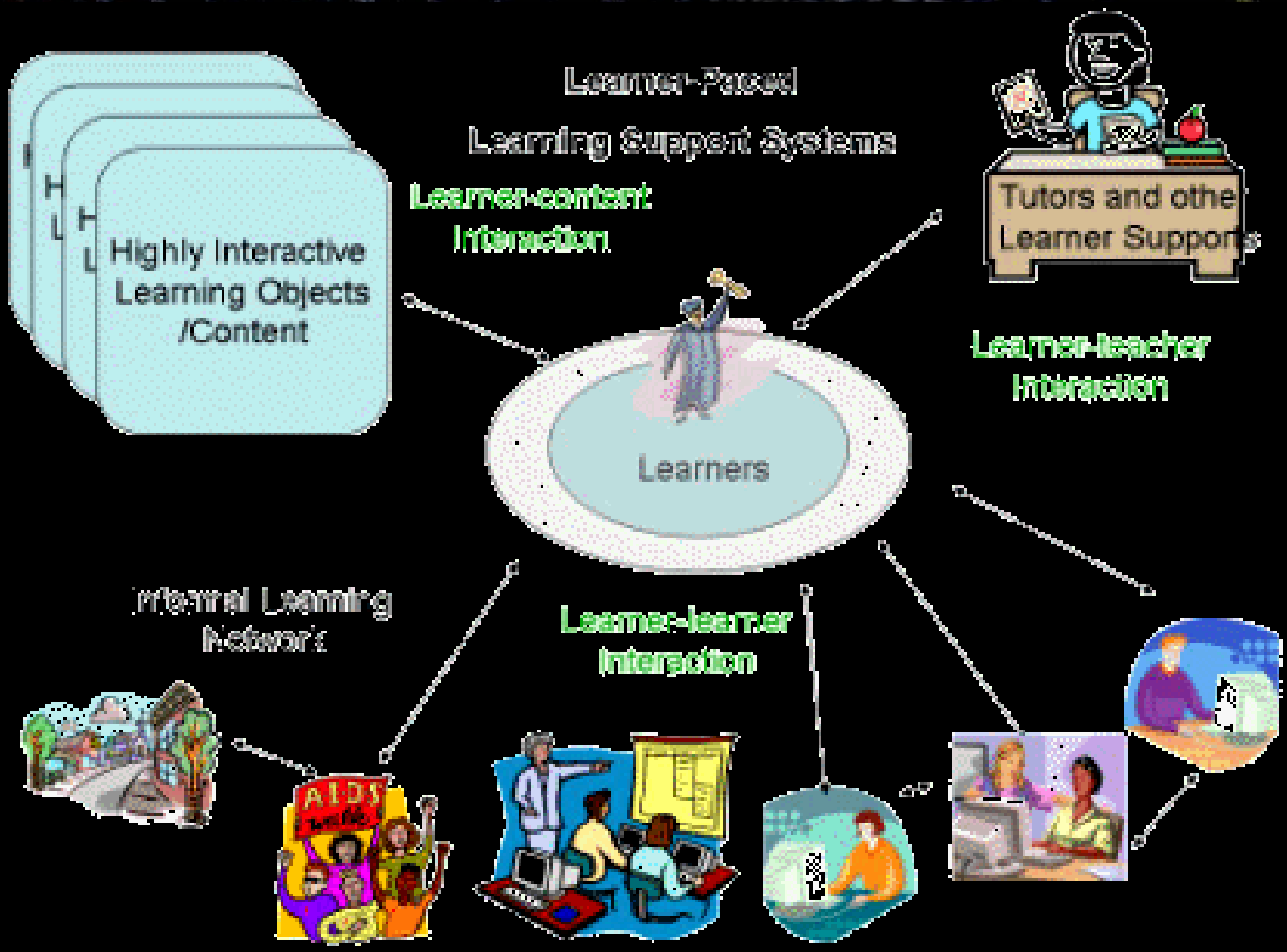


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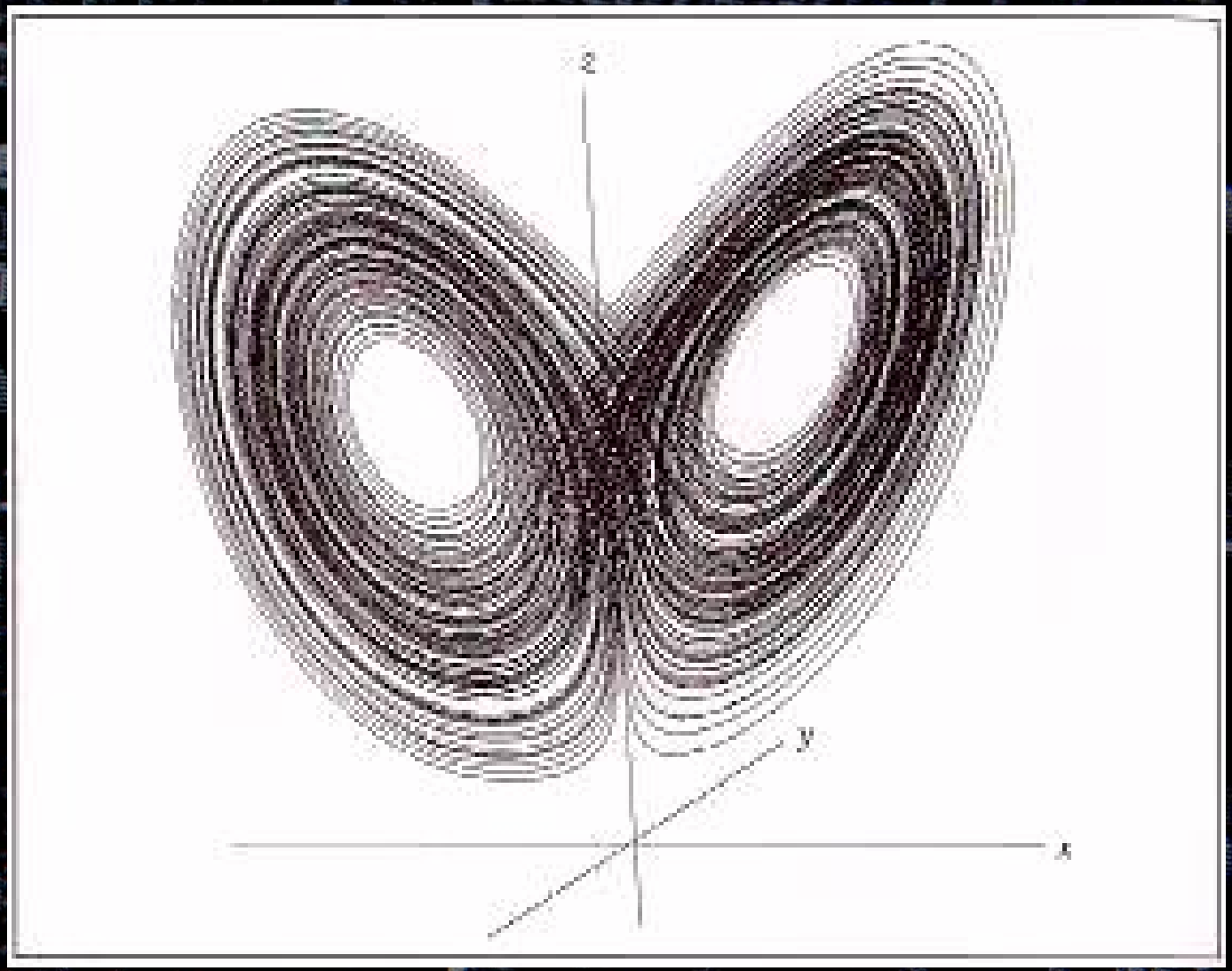


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# (Instructed) Language Acquisition

... fossilization (Selinker 1974, see also Birdsong 2005) ... avoidance (Schachter 1974) ... interlanguage (Selinker 1974) ... acquisition order (Dulay & Burt 1974) ... variety space (Klein and Dittmar 1979) ... input hypothesis (Krashen 1982) ... output hypothesis (Swain 1985) ... corpora in language learning (Johns 1991) ... role of context (Firth & Wagner 1997) ... chaos theory (Larsen-Freeman 1997) ...

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# … so what?

- language learning systems are dynamic, complex, non-linear, …
- but we have some knowledge about the nature of some variables, sub-processes and some ways of conceptualizing interesting fragments
- but still we don’t understand the interrelation of the language learning processes and some of the processes as such

# Student Models in ICALL

data about students (infer student knowledge from observed action)

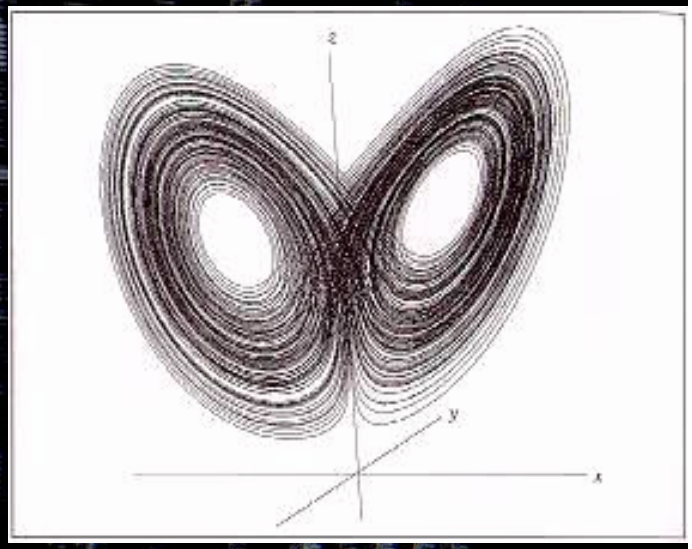
- bug libraries (e.g. Schuster 1986)
- perturbation (c. Kurtz, Chen and Huang 1990)
- model tracing technique (Tasso et al. 1992)
- machine learning (?)
- constraint-based models (Menzel 1988, Heift 1998)
- probabilistic models (?)

# … so what

- many of the models are extremely useful data structures
- but they often stop at reasoning about composite types or approximations of stereotypes
- wouldn’t it be nice if they predicted future student activity, so that a system could provide enabling conditions?

# Chaos Theory and Language Learning

- variability (learners, time)
- dynamic, complex, nonlinear, non-periodic, deterministic system (open)
- improved predictions of the immediate future
- strange attractors and repellents
- considers context, sensitivity to initial conditions, bifurcations?



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# Problems with modeling

- Should we analyze for chaos? emergence? (Larsen-Freeman 1997, de Bot et al. 2005)
- What data are we looking at?
  - text as product is a window into text as process
  - mastery/non-mastery/avoidance of linguistic surface representations (partial credit?, feature structures?)
- What equations? (Lorenz 1993, Williams 1997)
  - difference equations?
  - lagged phase space: $\mathbf{x_i(t+\Delta t) = f\,(x_i\,(t))}$
  - Multiple variables - not that many, but interrelated
- Mathematics not known or not proved (Liebovitch 2004)

# Ways forward …

- large datasets needed to identify deterministic mechanism
- sampling rate must cover attractor evenly
- choice of lag time important (allow for sufficient change)

- integrative, balanced view of SLA (Larsen-Freeman 2000)

# I wish you could help …

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(Birdsong, 2005; Chen & Kurtz, 1989; de Bot, Verspoor, & Lowie, 2005; Dulay & Burt, 1974; Firth & Wagner, 1997; Heift, 1998; Johns, King, & University of Birmingham. Centre for English Language Studies, 1991; Klein & Dittmar, 1979; Krashen, 1982; Larsen-Freeman, 1997; Menzel, 1988; Schachter, 1974; Schuster, 1986; Selinker, 1974; Swain, 1985; Tasso, Fum, & Giangrandi, 1992)

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