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Detecting Patterns of Dynamic Teacher-Learner Interactions in Online Adult Learning through a Dynamic Systems Approach

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Abstract: This study investigated dynamic teacher-learner interaction patterns in the context of adult online learning. The significance of this study is that it shows the applicability of dynamic systems approach in research on online adult learning. We employ a dynamic systems approach method, the State Space Grid, to capture dynamic interaction patterns between a teacher and learners. Results showed that the interaction patterns and their characteristics were distinct in each experimental class, but results also indicated that some interaction patterns were recurrent over the course. Research implications are briefly discussed.

Introduction

A number of studies have examined teacher-learner interaction in online learning environments to detect patterns of interactions that are particularly conducive for learning (e.g., Anderson, et al., 2001; Wang et al., 2001). As a class proceeds, the combinations of utterances of a teacher and learners dynamically change. For instance, when a teacher asks an open question at a particular moment, a learner may answer it spontaneously. A teacher may reframe what a learner said, or a teacher gives a simple comment to reply to what a learner mentioned. In this way, the combinations of a teacher and learners' utterances dynamically change in a classroom. This kind of change is deterministic under certain mechanisms, and called *deterministic chaos* in terms of dynamic systems theory (Kelso, 1995; Thelen & Smith, 1994).

In this paper, we describe the detection and visualization of complex and dynamic interaction patterns in online adult learning by utilizing one of the methods in dynamic systems approaches, the State Space Grid (Granic, Hollenstein, Dishion, & Patterson, 2003; Hollenstein, 2013; Lewis, Lamey, & Douglas, 1999). Prior research has utilized the approach in the context of parent-child interaction (Granic & Lamey, 2002); in the study presented in this paper, we apply it to teacher-student interaction to detect patterns and show how the patterns change over time.

Literature review

In the context of learning, interaction is often defined as "constructing knowledge together," and teacher's jointly constructing knowledge with students is seen as a hallmark of good tutoring (Brown, Collins, & Duguid, 1989; Wallace, 2003). Teachers distinguish themselves by adapting dialogue moves to students' evolving understandings, and students' response moves are indicative of their attention, cognitive engagement, and learning. For example, when a student displays a good understanding of a sub-topic, the teacher may introduce the next sub-topic with an open question, while if understanding is yet insufficient, a teacher may reframe a students' prior response. Hence, the analysis of dialogue moves, and, more precisely, of exchanges (an initiation-response pair, cf. Kneser, Pilkington & Treasure-Jones 2001), allows identifying effective dyads and broader exchange patterns (i.e., Anderson et al., 2001). While this research has theoretical benefits and can be used for teacher training, succinct representations of analyses of interactions (esp. visualizations, e.g., Shaffer, Collier & Ruis, 2016) will additionally benefit real-time or delayed intervention, and student assessment. Information on teacher-student interaction allows a teacher to detect recurrent group- or individual-specific response patterns, which may become grounds for real-time changes in interaction or pedagogical intervention.

Research questions

The research questions are: "What kinds of combination of utterances can be seen in the interaction between a teacher and learners?" and "How do the combinations change over the course?"

Method

Participants

11 Japanese adults participated in this study (two females and nine males). Their ages vary from early 30s to mid 50s. The professional backgrounds of the participants varied (e.g., CEO, business consultant, business/personal coach) The high variability of the participants allows inferences on the ability of the approach to detect recurring deterministic patterns. All of the participants voluntarily participated in this study.

Procedure

The data in this study are obtained from recordings of an online course held by the first author in 2015. The course consisted of 5 two-hour classes over two months. Teaching consisted primarily in discussing topics introduced in the first class of the course. The course aimed at offering academic and practical knowledge of adult development theory so that the participants can apply the knowledge to their professional fields.

The course utilized "Adobe Connect" which is an online meeting system similar to Skype. In the system, teachers can interact with learners, and learners with learners by both speaking and using a chat function. Turn-taking is structured by a microphone button: when a learner wanted to respond, s/he pushed the button. The discussion was structured so that each teacher utterance was followed by at most one student utterance. The data used in this study are only audio recordings.

The recordings of the 5 classes were transcribed and then translated into English. Two coders (the first and the third author) coded the utterances of teachers and students, utilizing a coding scheme developed for the purpose of this study. The coding scheme was developed using a Grounded Theory Approach (Glaser & Strauss, 1967); the coding categories are listed in table 1. The Cohen's Kappa statistic was .87, showing strong inter-rater reliability of the coding system.

Table 1: Codes for utterances of teacher (left column) and learners (right column)

Number	Teacher Utterance Category	Learner Utterance Category
1	Instruction	Spontaneous Simple Comment
2	Open Question	Spontaneous Meaningful Comment
3	Closed Question	Spontaneous Open Question
4	Encouraging Open Question	Spontaneous Closed Question
5	Encouraging Closed Question	Encouraged Simple Comment
6	Reframe Response	Encouraged Meaningful Comment
7	Simple Response	Encouraged Open Question

State Space Grid

State Space Grid (SSG) is a software program to analyze a dynamic system's behavior in a state space (Granic et al., 2003; Hollenstein, 2013; Lewis et al., 1999). The uniqueness of the method is to highlight recurrent patterns within the interaction of two state variables. The method can also generate automatically the trajectory of the change of interaction patterns. In addition, SSG can provide researchers with a number of indicators on the screen of the software to examine a specific characteristic of an interaction. An example is the indicator "Dispersion," which shows the distribution of the trajectory's cell visits. This is the percentage of visited cells to the whole grid.

At least two mutually exclusive variables are required to use SSG. Those mutually exclusive categories generate a grid of cells, each of which represents a categorical combination. In an actual case, SSG contains multiple cells, depending on the number of categories that a researcher chooses.

SSG has been used in research on child learning. Granic and Lamey (2002) apply SSG to examine the interaction in a parent-child dyad. The interaction is translated into a 4×4 matrix in a state space. The horizontal dimension represents four emotional variables of a parent such as hostile, negative, neutral, and positive. The vertical dimension depicts the same emotional variables of a child. Whenever the parent and child shift their emotions throughout the interaction, SSG can graphically trace each movement of the emotional patterns in the 4×4 matrix.

SSG can also find *attractor cells* in which interaction converges in a specific cell. Since formal cut-off criteria do not exist, this study applies a winnowing procedure (Levis et al., 1999; Hollenstein, 2013) to identify attractors. Any cells that are visited at least more than two times can be considered as attractor candidates. The next step is to winnow the candidate cells on the basis of the null hypothesis that all visits on the state space are equally distributed. This procedure consists of a series of runs, narrowing down the number of the candidate cells to a small set of cells.

Data quantification

The total number of the turn-by-turn utterances over the course was 458. Whereas the number of teacher's utterances was 229, that of learners' utterances was 229. Each utterance was quantified with a specific number in the coding system. One interaction turn between the teacher and learners was counted as one. Therefore, the

total amount of interaction is 229. The mean number of student utterances (over all classes) was 19.18 (*SD* = 9.73). This indicates that the learners contributed more or less equally to the discussion in the course.

Results

Interaction patterns and the trajectories

The research questions address what types of combination of utterances can be seen in each class and how the combinations change over the course. SSG generated the following figures (See Figure 1). Each numeric symbol in the figures corresponds with the contents in Table 1.

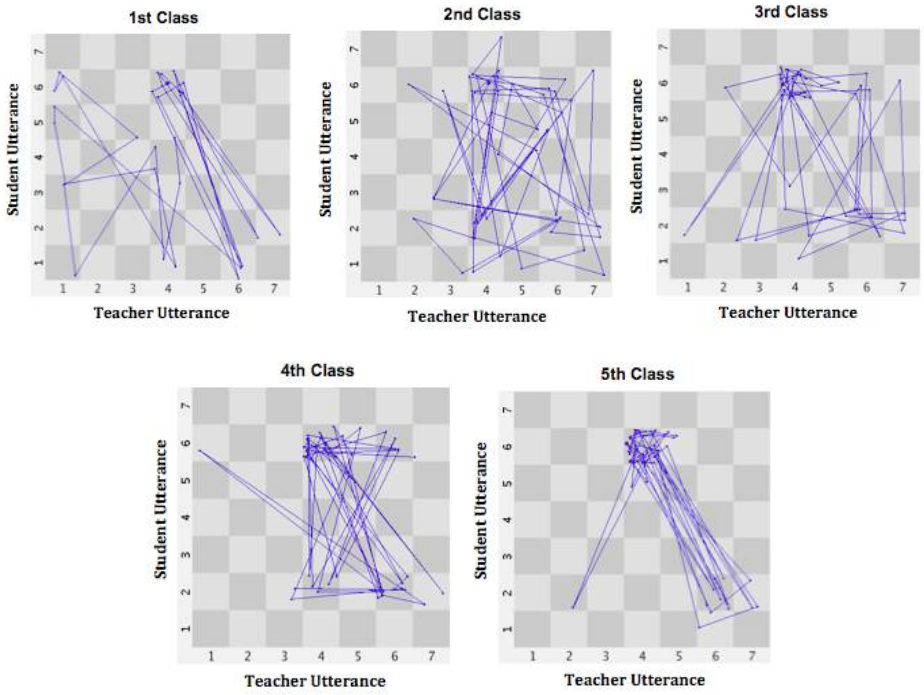

Figure 1. State space grids for five classes in terms of behaviors.

Figure 1 illustrates that each class showed different types of trajectories. It also demonstrates that a couple of cells frequently appeared. E.g., (Teacher utterance, Learner utterance) = (4, 6). The figures also shows that some combinations occurred less frequently (i.e., (1, 1), (4, 1), (7, 2)).

One captivating phenomenon is that the teacher started to frequently use "reframe response" from the second class. One reason might be related with the fact that the learning environment of the first class was more conventional than the other classes in that the teacher had to explain the purpose and structure of the course and had to offer theoretical instructions so that the learners can deepen the discussion in the succeeding classes. Another reason for the increase of the teacher's reframe response is that the teacher might have intended to give the learners an opportunity to elaborate their thoughts in a different way instead of asking questions.

Moreover, except for the first and second class, the teacher's reframe responses began to elicit learners' spontaneous meaningful comments, which resulted in generating the attractor cell (6, 2) from the third class toward the end of the course. It was a transitional moment for such an interaction-oriented learning environment as the course in this study because the fundamental purpose of such a course is to involve learners in a classroom discussion and encourage them to make a spontaneous comment rather than a passive simple comment. In that sense, it was a positive result that the number of the learners' spontaneous meaningful comments began to increase from the third class toward the end of the course.

Finally, besides the increase of the learners' specific utterances, it is worth focusing on what types of their utterances decreased over the course. Interestingly, the learners stopped asking spontaneous open and closed questions from the third class on. At first glance, the decrease of questions can be seen as negative. However, this is not a necessarily negative phenomenon because the learners began to make more spontaneous comments instead of asking questions. As mentioned before, the first class was a traditional learning environment in that the teacher had to offer some theoretical instructions, and thus, it is reasonable to speculate

that the learners asked spontaneous questions in the first class to clarify their understanding of the lecture. In addition, it is understandable that the learners still asked spontaneous questions in the second class to digest the first class's lecture. Through such a process, the learners might have begun to replace spontaneous questions with spontaneous comments from the third class.

Discussion

The characteristics of combinations of utterances identified by this study offer rich information on the dynamic nature of the teacher-learner interaction. If we focused only on either a teacher or learners, we would not detect such a dynamic process of interaction. In sum, this study suggests researchers that a study on dynamic interaction processes should not examine variables separately but investigate combination of variables that characterize the interaction. Also, SSG enables us to explore the trajectories of change of interaction patterns.

Prior studies (e.g., Granic & Lamey, 2002; Granic et al., 2003) examined the dynamic interaction between an adult and children to make inferences on children's cognitive development. Our study suggests that our approach is viable also for teacher-learner interaction in online adult learning. Clearly, the advantages of our approach over others must be ascertained through comparative analyses, including the identification of recurrent dyads and patterns by humans. The potential of this approach must be considered also in relation to the automated detection of dialogue moves (i.e., D'Mello, Olney, & Person, 2010); combining analyses and visualization capabilities would contribute to the field of learning analytics.

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