3 A DYNAMICAL PERSPECTIVE ON LEARNER INTERACTION

This chapter develops a dynamical perspective on learner interaction. The purpose of the dynamical perspective is two-fold. The first is to define what is meant by the *dynamics of learner interaction*, and thereby clarify the research aims outlined in chapter one. The other is to provide principles that can guide the formulation of research questions, the collection of learner interaction data, the development of a visualisation technique, and the eventual application of the visualisation to learner interaction data.

The chapter begins by presenting two existing frameworks for researching interaction that, as yet, have not been used in research on interaction between language learners. The first of these, Cameron's (2003) complex systems framework for the study of classroom talk, introduces a dynamical conceptualisation of classroom interaction, and views classroom talk as regulating, or mediating, this interaction as it unfolds in time. The second framework, Fisher and Granott's (1995) microdevelopmental analysis of problem-solving activity, provides some important additional insights used in the eventual formulation of the dynamical perspective. In particular, Fischer and Granott introduce a multi-level analysis of problem-solving interaction, and suggest a visual method for exploring the dynamics of this interaction. The second section of the chapter outlines the dynamical perspective on learner interaction itself. This includes separate discussions of the influences of complex systems theory and sociocultural theory. The section also introduces a framework suggested by Pianta and Walsh (1996) for identifying change processes in social systems. This framework is suggested as useful for the analysis of changes in the dynamics of learner interaction across series of similar classroom activities. A final section outlines implications of the dynamical perspective for the collection of learner interaction data, the transcription of this data, as well as the visualisation of the dynamics of learner interaction.

3.1 Related Dynamical Frameworks

This section reviews Cameron's (1999; 2001; 2002; 2003) complex systems framework for understanding and researching classroom talk, and Fischer and Granott's (1995) framework for multi-dimensional analysis of problem-solving interaction. Both of these frameworks make critical contributions to the dynamical perspective on learner interaction to be developed in the subsequent section.

3.1.1 Classroom Talk as a Complex System

Two elements of Cameron's (1999; 2001; 2002; 2003) complex systems framework of classroom talk are of particular value for the present research. The first is Cameron's conceptualisation of how classroom interaction is achieved through what she, after Slobin (1996), calls *talking-and-thinking* (cf. Cameron, 2002, 2003). The second is her conceptualisation of classroom tasks as dynamic environments, or ecologies, for language use and learning, as well as how these dynamic environments can be understood from a pedagogical perspective (cf. Cameron, 2001). These two elements are discussed in turn.

One purpose of Cameron's framework is to develop a complex systems framework for understanding the role of metaphor in educational discourse (cf. 2002, 2003). This framework draws on sociocultural theory to conceptualise metaphor as a psychological tool, or means, in talking-and-thinking in teacher-pupil interaction. The framework is dynamic in that it sees talking-and-thinking as an inter-mental dynamic process that is contingent on interaction as it unfolds in time. In this dynamic conceptualisation of talking-and-thinking, the teacher uses metaphors to manage the difference in knowledge and understanding between herself and her pupils, resulting in pupils' restructured knowledge and understanding. In order to elaborate on how talking-and-thinking is contingent on interaction as it unfolds in time, Cameron uses insights from complex systems theory. She describes individuals as having complex dynamic systems of linguistic, cognitive and affective resources, and that these resource systems co-adapt in talking-and-thinking to create the dynamical environment of the task-in-action.

The significance of this first element of Cameron's framework lies not in its focus on metaphor as a means in talking-and-thinking. In fact, this aspect of Cameron's framework has been de-emphasised in the above (as have other important elements of her framework). Rather, its significance is that talking-and-thinking, more generally, can be seen as the means by which language classroom interaction is realised, and therefore also the means by which learner interaction is realised.

A second element of Cameron's framework is the distinction between *task-as-plan* and *task-in-action* (cf. 1999; 2001; for a related distinction cf. Breen, 1987). Task-as-plan is conceptualised as "the initial conditions for the use of English by pupils" (2001, p. 43), and as this task-as-plan unfolds in an actual classroom, "it creates the environment of language use and learning" (2001, p. 43), which is called task-in-action. Furthermore, the framework suggests that the learning potential of tasks can be analysed in terms of "the *demands on learners* and *support for learning*" (2001, p. 21; original emphases) provided by the task-in-action environment. For a task to be successful it must achieve an appropriate balance between such demands and support, and this balance is assessed in terms of the principles outlined by Vygotsky's (1978) Zone of Proximal Development (ZPD). An appropriate

balance, therefore, is achieved in a task that is "*demanding but not too demanding*, that provides *support but not too much support*" (2001, p. 27; original emphases), and where the "*difference between demands and support* creates the space for growth and produces opportunities for learning" (2001, p. 27; original emphasis).

The potential value for the research aims of this second element of Cameron's framework is that task-as-plan, as the initial condition from which the dynamical task-in-action unfolds, allows the specification of an initial set of task demands and support which will affect interaction as it unfolds. Moreover, talking-and-thinking, as the means through which interaction is realised, affects both the dynamics of this interaction, and the continually changing demands and support.

3.1.2 Microdevelopmental Analysis

Fischer and Granott's (1995) framework for microdevelopmental analysis of problem-solving interaction adds another two elements that are of potential value to the present research. The first is their conceptualisation of problem-solving interaction as functioning on multiple concurrent levels of activity. The other is their use of the visual mode to represent and understand these multiple levels of activity. Moreover, both of these elements are explicitly motivated by the need to incorporate the time-dimension in analysis.

Fischer and Granott present their framework as a response to three prevailing one-dimensional assumptions, which they claim prevents research taking an ecological and multi-dimensional path. These three assumptions are (1995, p. 304-305):

1. Single-person assumption: people learn and develop as individuals, who sometimes interact and influence each other;
2. Single-level assumption: At any one moment a person functions at a single cognitive stage or a single level of complexity;
3. Single-shape assumption: Each developmental pathway shows basically the same shape - linear or at least monotonic increase.

Fischer and Granott argue that in order to understand learning and development together, that is, to make links across the distinct timescales that differentiate learning and development, research should instead (1995, p. 305):

- Focus on how ensembles of individuals learn and develop together.
- Recognize that people develop and learn along multiple concurrent strands and threads in a developmental web.
- Try to describe the complex non-linear fits and starts of actual learning and development.

The researchers illustrate such an agenda by analysing a problem-solving activity, in which two adults try to work out the operation of a Lego robot. Their analysis proceeds by visually plotting two concurrent, but distinct, *activity threads* present in the interaction in the time dimension. The first activity thread was the participants' *understanding of the robot*. Since this activity thread showed progression in the visual representation (in the form of increased understanding over time) they referred to this as a microdevelopmental activity thread. Furthermore, Fischer and Granott comment that this microdevelopmental activity thread showed a similar developmental trajectory as occurs in long-term development. They describe this trajectory as "nonlinear, dynamic microdevelopment, with up-and-down oscillations, gradually moving from simple skills to increasingly complex actions and representations" (1995, p. 309). Finally, the researchers point out that progression in this activity thread, including its dynamic fits and starts, "was shared across the two members of the ensemble. The collaboration was pervasive" (1995, p. 309).

The second activity thread which Fischer and Granott plotted was *communicating about the task*. This activity thread did not show any progression in the visual representation. Rather, the trajectory started at a high level of sophistication, and despite similar nonlinear 'fits and starts' as was observed in the microdevelopmental activity thread, it largely remained at this sophisticated level throughout the timescale of observation. Fischer and Granott concluded, "the two threads show distinctive patterns even though both are contained in the same activities" (1995, p. 311).

In relation to the present research aims, the significance of Fischer and Granott's framework lies in their conceptualisation of interaction as functioning on multiple concurrent levels, or what they call activity threads, as well as their suggestion to visualise these activity threads. Developing a method for visualising the dynamics of learner interaction may also benefit from such a multi-level perspective. Another potentially significant point is Fischer and Granott's claim that focusing on multiple activity threads makes available relationships between different timescales (in this case learning versus development). More generally, Fischer and Granott's multi-level visualisation makes transparent the contribution of the different activity threads in the dynamics of the problem-solving interaction they seek to understand. Hence, it may be that relationships between activity threads can be used to account for the dynamics of learner interaction in classroom activities. Finally, it might be possible to use a similar visual technique for making transparent the contributions of different activity threads in learner interaction.

3.2 A Dynamical Perspective

This section draws on the frameworks introduced in the previous section, as well as on concepts and terminology from complex systems theory (henceforth CST) and sociocultural theory, to outline a dynamical perspective on learner interaction.

The use of concepts and terminology from CST falls short of actually saying that learner interaction is *taken to be* a complex system in the physical, biological, or mathematical sense (which are fields from which CST originated; cf. Cohen & Stewart, 1994; Gleick, 1987; Kauffman, 1995). Rather, the use of CST makes available terminology and concepts, and thereby a way of *thinking*, which may facilitate a better understanding of the dynamical nature of social processes (Sower, 1997; Pianta and Walsh, 1996), including learner interaction. What is implied, therefore, is that learner interaction can *be understood as* a complex system. Note that this interpretation is similar to Cameron's (cf. 2003) use of CST, as well as the microdevelopmental perspective's use of related insights from ecological and dynamical systems theories (cf. Granott & Parziale, 2002a). Furthermore, recent research in applied linguistics has illustrated the potential usefulness of CST, as well as related dynamical perspectives, such as e.g., dynamical systems theory. This includes general suggestions for using CST in applied linguistics research (e.g., Bleyhl, 1997; Larsen-Freeman, 1997), theoretical explanations of language, language use, language learning and language change (e.g., Andersen, 2002; Ellis, 1998; Elman, 1995; Herdina & Jessner, 2002; Petitot, 1995), implementations of dynamical systems and cellular automata models that exhibit some of the same qualities as real-world language use, language learning and language change (e.g., Meara, 1999a, 1999b; Niyogi & Berwick, 1998; Knudsen & Cameron, 2000; Tabor, Juliano & Tanenhaus, 1997), as well as empirical studies of language use and language learning (e.g., Cameron, 1999, 2003; Syversen, 1999).

The parallels between CST and sociocultural theory have been noted by a number of authors. Cameron's CST framework of classroom talk and interaction makes explicit use of sociocultural theory, both in its conceptualisation of demands and support for learning (cf. 2001), and in the conceptualisation of talking-and-thinking (cf. 2002, 2003). Thelen and Smith (1994) also comment on this parallel in their dynamic systems analyses of infant motor development. Finally, van Geert (1994, 1999) and Granott (2002), independently from each other, have provided dynamical re-conceptualisations of Vygotsky's (1978) Zone of Proximal Development.

The use of sociocultural theory in conjunction with CST also counters those authors who argue against uncritically using concepts and tools developed in the physical, biological and mathematical sciences for understanding social processes (e.g., Eliasmith, 1996; Faber & Koppelaar, 1994; Hunter & Benson, 1997). In this respect, the present development of a

dynamical perspective follows the advice given by Puddifot (2000), who argues that if CST is to be an influence in social research it must interface with process explanations native to the social sciences. The use of sociocultural theory, therefore, with its established body of research on learner interaction (cf. section 2.3), serves as a process explanation native to applied linguistics.

The next two sub-sections formulate the dynamical perspective on learner interaction, including discussion of CST and sociocultural influences, respectively.

3.2.1 Learner Interaction as a Complex System

Cameron's distinction between task-as-plan and task-in-action, and Fischer and Granott's conceptualisation of interaction as functioning on multiple concurrent activity threads, forms the starting point for this discussion of learner interaction as a complex system (cf. section 3.1).

Cameron's framework sees a task-as-plan as setting "the initial conditions for the use of English by pupils" (2001, p. 43), and as this task-as-plan unfolds in an actual classroom, "it creates the environment of language use and learning" (2001, p. 43), which is called task-in-action. The present conceptualisation of the dynamics of learner interaction is similar to Cameron's task-in-action. However, for the purposes of the present research aims, the exact meaning of the dynamics of learner interaction needs to be elaborated further.

A useful first step towards making clear the exact meaning of the dynamics of learner interaction is to clarify three possible perspectives on activity, each of which contributes to the dynamics of learner interaction. The first two perspectives relate to a distinction suggested by Bales and Strodtbeck's (1967) research on problem-solving interaction. These authors make a distinction between "conditions which may be regarded as constituted prior to the period of observation, and those that arise and change during the actual period of observation" (1967, p. 90). That is, a first perspective on activity is those conditions, in the form of participants' experiences and expectations, that arise *before* an activity commences. This is similar to Cameron's description of individuals having complex dynamic systems of linguistic, cognitive and affective resources that co-adapt to create the dynamical environment of the task-in-action. The second perspective on activity, following Bales and Strodtbeck, relates to those conditions, again in the form of experiences and expectations, which arise *during* the activity in question. This perspective is similar to what van Lier (1988) refers to as a micro view of context. That is, van Lier describes a micro view of context as a "discoursal or interactive context (or context in performance)" (1988, p. 8). A final perspective on activity relates to the initial conditions created by a task-as-plan, as outlined by Cameron's framework (2001; cf. section 3.1.1). This task-as-plan may be seen as a snapshot in time associated with

the moment an activity begins. After this moment in time, the activity will proceed along a 'trajectory', which over time, to a greater or lesser extent, is affected by the task-as-plan.

The purpose of the above outline of three perspectives on activity is to avoid the possible misconception that the dynamics of learner interaction only includes those conditions arising and changing during the activity in question. Rather, the dynamics of learner interaction is viewed as *a coming together of* 1) experiences and expectations that arise *before* an activity commences, 2) experiences and expectations that arise *during* the activity in question, and 3) the initial conditions created by the task-as-plan.

A second step towards making clear the present meaning of the dynamics of learner interaction relates to Fischer and Granott's view of problem-solving interaction as functioning on multiple concurrent activity threads (cf. sub-section 3.1.2). Fischer and Granott describe this as follows,

> In development, a person moves through a web of connected pathways composed of multiple strands (domains, tasks), each involving different developmental levels ... In addition, there is a diversity of levels within each strand, because every strand is composed of multiple threads, like a rope or a string. Each thread comprises a different dimension of activity within a given task or situation. (1995, p. 304)

Hence, the full metaphor includes both *activity strands* and *activity threads*, with strands signifying a domain or task, and threads being different levels within each strand. However, Fischer and Granott do not provide any concrete examples of *activity strands* in their research.

From a CST perspective, an important feature of Fischer and Granott's activity strands and threads is that they have emergent properties. Following MacWhinney (1999), the activity strands and threads may be seen to exhibit *online emergent* properties. Online emergent accounts of language development are concerned with investigating "the ways in which language structure emerges from the activities of speaking and listening" (MacWhinney, 1999, p. xi). Taking the example of Fischer and Granott's (1995), they made the observation that, on a given timescale, one activity thread showed progression (understanding the Lego robot), while another activity thread showed no evidence of progression (communicating about the task). Consistent with an online emergent perspective, Fischer and Granott argue that the plotted sequence of understanding the Lego robot "followed the same progression through skill levels that occurs in long-term development, thus demonstrating a parallelism between micro- and macrodevelopment" (1995, p. 308). However, although such online emergence may be a quality of learner interaction, the present research also aims to account for those dynamics of interaction that are not specifically related to learning, or the development of language structures. That is, the research aims to understand *interaction* more

generally. Hence, the present research will likely need to identify a greater number of activity strands and threads, and will have to adopt a broader notion of emergence.

Such a broader notion of emergence may be illustrated by highlighting a second way in which the two activity threads, which Fischer and Granott observed, might be related to each other, and by how they might be related to the coming together of the three perspectives on activity outlined above. Once again, Fischer and Granott observed one activity thread defined as 'understanding the Lego robot', and another activity thread defined as 'communicating about the task'. In a broader notion of emergence the visualisations of the two activity threads may be seen as two different *traces* of the activity in question. In other words, 'understanding the Lego robot' and 'communicating about the task' are both traces of the same activity (cf. Byrne, 2002 for a similar use of the term 'traces'). Consequently, each of these traces, in the form of activity threads, reflects the coming together of the three perspectives on activity outlined above. The argument, then, is that the dynamics of this activity can be better understood by identifying relationships between these different traces, or activity threads. More generally, the same might apply to activity strands, and between activity strands and threads. In other words, identifying any and all relationships between activity strands and threads constitutes a broader notion of emergence. More importantly, since the activity strands and threads are traces of the coming together of the three perspectives on activity outlined above, relationships between strands and threads reflect the dynamics of learner interaction.

Finally, a fundamental principle of an emergent account is that of non-reducibility. That is, no emergent feature can be explained as the simple sum of its separate parts. Hence, the dynamics of learner interaction cannot be explained as the simple sum of different activity strands and threads. Rather, it is the relationships between activity strands and threads that reveal the dynamics of learner interaction. This also means that no single strand or thread can be explained in terms of any other strand or thread. Again returning to the example given by Fischer and Granott's (1995) research, 'understanding the Lego robot' is qualitatively different from, and non-reducible in terms of, 'communicating about the task', and vice versa.

The non-reducible character of activity strands and threads, as defined here, has two implications. One is that the identification of relationships between strands and threads may not take the form of a mathematical or logical formalism. This reinforces the potential utility of visualisation, which may reveal less formally defined relationships. The second implication is that the identification and coding of separate activity strands and threads, being non-reducible in terms of any other strands or threads, might require different analytical means. That is, a different analytical method may be required in the identification and coding of each activity strand and thread.

To summarise, the dynamics of learner interaction is viewed as *a coming together of* 1) experiences and expectations that arise *before* an activity commences, 2) experiences and expectations that arise *during* the activity in question, and 3) the initial conditions created by the task-as-plan. Moreover, learner interaction can be viewed as constituted by multiple activity strands and threads, and relationships between these activity strands and threads reflect the dynamics of the learner interaction. Finally, these activity strands and threads exhibit emergent properties, will therefore be non-reducible in terms of each other, and might require different analytical means for their identification.

3.2.2 Learner Interaction and Sociocultural Theory

In the traditional view of human evolution and development individuals are seen to cause the emergence of the social (Sinha, 2000). That is, in this traditional view, individuals are the fundamental starting point for research into both psychological and social processes. The sociocultural alternative, while far from fully developed (Cole, 1995), instead sees the individual and social levels as mutually constitutive (Cole, 1999). Furthermore, the fundamental starting point for research into both psychological and social processes is *interaction* between individuals (cf. Wertsch, 1991). This fundamental nature of interaction has three implications that will be discussed in the following. The first is how context might be conceptualised when interaction between individuals is taken as fundamental. This is followed by a discussion of how interaction can be investigated from a sociocultural perspective. Finally, the relationship between the conceptualisation of context, how interaction can be investigated, and Cameron's framework for assessing demands on learners and support for learning is discussed.

The traditional view of human evolution and development often uses the visual metaphor of concentric circles to describe contexts (Cole, 1999). For example, a context may be pictured with an individual person in the centre. Increasingly social levels, such as e.g., interaction between individuals, task, classroom, school and community, can be drawn as circles with increasing diameters around the individual. However, this visual metaphor privileges the individual as the starting point of any analysis, and is therefore incompatible with the fundamental nature of interaction in sociocultural research. Moreover, it does not incorporate the time-dimension, which the present research seeks to include.

Cole (1999) instead suggests the visual metaphor of a rope, as in threads woven into strands and strands woven into a rope, as a more appropriate visual metaphor for context in sociocultural research. Consistent with the above outline of learner interaction as a complex system, and following the suggestion of Fischer and Granott (cf. the previous sub-section), learners doing an activity together, learners talking about the activity, learners making

progress in the activity, and so on, may constitute the strands and threads that weave together to form the context of an activity. In other words, the learners' interaction is the fundamental starting point in this metaphor of context.

The visual metaphor of a rope also takes into account the time-dimension. That is, the metaphor includes both a synchronic dimension, as in threads woven into strands and strands woven into a rope, and a time-dimension, represented by the continuous weaving together of new lengths of rope. That is, following Fischer and Granott (1995), the synchronic dimension are the different perspectives on what the learners do together, in interaction (i.e., the activity strands and threads). The time-dimension, by contrast, is the constant unfolding of what the learners are doing together, in interaction, and over time (i.e., the continual weaving together of activity strands and threads).

Moving on, now, to a discussion of how interaction can be investigated from a sociocultural perspective. According to Vygotsky, any mental activity requires some type of cognitive tool (1997). In spoken interaction between individuals this cognitive tool is language. Moreover, this use of language in interaction also makes it a social tool, and in educational contexts, a pedagogical tool as well (Mercer, 2001). Finally, in the case of learner interaction, it is the participants' *learner talk* that is the cognitive, social and pedagogical tool, which realises the interaction. Hence, the object of investigation from a sociocultural perspective is learner talk (cf. also discussion in section 2.3). In other words, the participants' learner talk will be primary in identifying different activity strands and threads, as outlined in the above discussion of learner interaction as a complex system (cf. sub-section 3.2.1).

The conceptualisation of learner talk as a cognitive, social and pedagogic tool, which realises interaction, is consistent with Cameron's (2002, 2003) conceptualisation of talking-and-thinking (cf. section 3.1.1). Slobin, who motivated Cameron's adoption of these terms, describes this as "a special kind of thinking that is intimately tied to language - namely, the thinking that is carried out, on-line, in the process of speaking" (1996, p. 75). In other words, learner talk, through the concept of talking-and-thinking, not only realises the interaction between participants, it also reflects the participants' thinking during interaction.

Finally, turning now to the relationship between the above conceptualisations of context and learner talk, and Cameron's (2001) framework of demands on learners and support for learning. The discussion of Cameron's framework, in sub-section 3.1.1, suggested that the pedagogical potential of task-in-action could be analysed in terms of the continually changing demands on learners and support for learning. Moreover, it was also suggested that talking-and-thinking affects both the dynamics of the task-in-action and the continually changing demands and support. Hence, in the case of learner interaction, learner talk, conceptualised as talking-and-thinking, affects both the dynamics of learner interaction and the continually changing demands and support, as a classroom activity unfolds. This means that learner talk

can be used to establish a *link* between the outcomes of visualisation, i.e., the dynamics of learner interaction, and the continually changing demands and support in a classroom activity. In other words, an in-depth analysis of the outcomes of visualisation, which was suggested by the review of sociocultural research in chapter two (cf. section 2.4), could focus on how the learner talk that is associated with the outcomes of visualisation affects the demands and support in a classroom activity.

3.2.3 Conceptualising Change Across Similar Activities

One of the specific research aims of the study is to visualise changes in the dynamics of learner interaction across a series of similar language classroom activities (cf. section 1.1). While the above outline of a dynamical perspective on learner interaction addresses part of this research aim, it does not address how changes in the dynamics of learner interaction may be identified. An analytic perspective suggested by Dale and Davies (1994) offers a possible starting point for such an analysis.

> Where individuals are surveyed at successive time points, then it is possible to investigate how individual outcomes or responses are related to the earlier circumstances *of the same individuals*. This provides the framework for very powerful analyses of the processes experienced by individuals; it enables a model to be constructed which explicitly takes into account the earlier circumstances suspected to have an effect which carries through into later life. (quoted in Byrne, 1998, p. 67; original emphasis)

From a CST perspective, the most important point that Dale and Davies make is that the analysis should be directional, i.e., the analysis should look for effects that follow the 'arrow of time'. In practice, this means that the dynamics of participants' learner interaction in an *earlier* activity might affect the dynamics of their learner interaction on similar *later* activities.

Pianta and Walsh (1996) offer a complex systems conceptualisation of change processes affecting high-risk children in schools. This same conceptualisation may be used to describe changes in the dynamics of learner interaction across similar classroom activities. Pianta and Walsh suggest three different change processes in their research. They call the first form of change *self-stabilization*. This is a situation where a system rearranges "internal dynamics or relations and adapts to pressure without altering its basic structure or identity" (Pianta & Walsh, 1996, p. 90). Self-stabilization is similar to the more common notion of *first-order change*, which is defined as changes "within a given system which itself remains unchanged" (Watzlawick, Weakland & Fisch, quoted in Golembiewski, Billingsley & Yeager, 1976, p. 140). The second type of change process that Pianta and Walsh suggest in their research is

adaptive self-reorganization. This is a situation where "the self-stabilizing properties of the system are inadequate to meet the demands placed on them, and the system must reorganize [its basic structure or identity] in order to respond adaptively" (Pianta & Walsh, 1996, p. 90). This change is similar to so-called *second-order change*, which is a change that 'changes the system itself' (Watzlawick et al., quoted in Golembiewski et al., 1976, p. 140). The final type of change suggested by Pianta and Walsh is a situation where the self-stabilizing properties of a system are inadequate to meet the demands placed on them, and where at the same time any self-reorganizing response of the system fails to be adaptive. In such cases the outcome is a *breakdown* in the system.

In sum, the dynamics of learner interaction in earlier activities may be used to ascertain changes in the dynamics of learner interaction in later classroom activities. Moreover, the changes in dynamics may be described in terms of the three change processes suggested by Pianta and Walsh (1996), and outlined in the above. Finally, these change processes may be associated with the relationships between activity strands and threads. However, this will only become clear once the visualisation of learner interaction is developed in full.

3.3 Implications for the Research

This final section outlines the implications of the dynamical perspective for the present research. The discussion includes implications for the collection of learner interaction data, transcription of this data, as well as the visualisation of the dynamics of learner interaction.

There is a clear implication of the dynamical perspective for the collection of learner interaction data. Learner talk was emphasised as the object of investigation in sociocultural research (cf. sub-section 3.2.2). Hence, the research should collect data on the spoken discourse that the participants produce during learner interaction. In fact, since learner talk will be the primary evidence for identifying activity strands and threads, the participants' spoken discourse will be the primary data on which the study will rely.

Since the research will collect data on the participants' learner talk, the first form of representation of this primary data will likely be in the form of transcription. This transcription must take into account the notion of talking-and-thinking adopted by the dynamical perspective. However, unlike Cameron's research (cf. 2003), which examines metaphor as the unit of talking-and-thinking, the present study seeks to identify, visually represent, and analyse a number of different activity strands and threads, each of which may require a different analytical means for its identification. Hence, there is a need for a unit of transcription that not only reflects the notion of talking-and-thinking, but which also provides sufficient detail to code a number of different activity strands and threads.

An implication that is directly related to visualisation is that the dynamical perspective, and in particular the research by Fischer and Granott (1995), suggests that visualisation can be a useful method for exploring the dynamics of learner interaction. In particular, Fischer and Granott's research suggests that visualisation may be an effective method for representing the activity strands and threads that reflect the dynamics of learner interaction. This indicates that a visualisation technique for displaying multiple activity strands and threads in the time-dimension should be developed. Given the adoption of a broader notion of emergence, this visualisation technique must be able to display a wide range of activity strands and threads, and to facilitate the identification of relationships between these different activity strands and threads.

A further implication of the broader notion of emergence is that each activity strand and thread is non-reducible in terms of any other activity strand or thread (cf. sub-section 3.2.1). This means that the identification of each different activity strand and thread may have to be based on a different analytical perspective. Beyond this, it is difficult to say exactly what perspectives on learner interaction the different activity strands and threads may represent. The only precedent for activity strands and threads, as they are conceptualised here, are the two activity threads formulated by Fischer and Granott in their research on problem-solving behaviour (cf. sub-section 3.1.2). In other words, the coding of the learner interaction data into activity strands and threads is likely to be an eclectic exercise. Moreover, neither Fischer and Granott (1995), nor Cole (1999), provides any concrete example of what *activity strands* are. Hence, making clear the difference between activity strands and activity threads will be a further feature of the coding, and also the analysis, of the learner interaction data.