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## 9: Ecological perspectives on CALL

Regine Hampel

### **Introduction**

The focus of this handbook is on language learning and technologies, and the different chapters illustrate the impact of the introduction of digital and online technologies on how a second language is learned and used – with the COVID-19 pandemic accelerating the adoption of the digital media for personal use as well as in educational contexts. This chapter explores the ways in which more recently technology-enhanced language learning and teaching has been theoretically framed by ecological theories, influenced by an emergentist approach to cognition that focuses on the interaction between an organism and its environment. One theory that is particularly useful for exploring the changes in how we communicate and how we learn today is complex dynamic systems theory (CDST). It reflects an approach designed to deal with phenomena that consist of multiple, interconnected variables (Godwin-Jones, 2018) and allows us to examine entities engaged in dynamic processes – such as a group of people with different first languages using a second language in an online gaming environment, or two language classes with different first languages communicating with one another.

To take account of the increasingly technologized contexts of language learning and teaching today, as well as the importance of interaction in second language learning and of the multiple modes available for meaning-making, I will link CDST with sociocultural theory and semiotics (the multimodal theory of communication and multiliteracies, to be precise). The chapter will illustrate the disruptive effect of the digital media on meaning-making in the traditional language classroom, transforming the more traditional interaction patterns, communication modes and the positioning of the language learner in relation to the world

(see Hampel 2019). The reader should take note though that the term 'disruption' is used here not in a negative way but in order to convey a radical change.

## **Emergentism**

The notion of emergence developed in the early 2000s as a key concept in the natural sciences, particularly in complexity science, where it is used to elucidate the evolution of more complex forms through simple rules. According to Solé and Goodwin (2000), emergence helps us to tackle the question how systems made up of components whose properties we understand well can give rise to phenomena that are quite unexpected.

At the same time, cognitive approaches to language acquisition were starting to be queried, with applied linguists keen to explore alternative theories to enhance our understanding of language learning and teaching. Thus emergentism was introduced into applied linguistics, providing a new angle on second language acquisition. Ellis (2003) explains what this means: "the complexity of language emerges from relatively simple developmental processes being exposed to a massive and complex environment" (p. 81) – in ways that are similar to natural changes as explored in geology or meteorology. This way of understanding language learning stresses the interaction between organism and environment and focuses on the *process* of acquisition rather than the language acquisition *device*. Similarly, Gregg (2003) summarizes emergentism as "an approach to cognition that stresses the interaction between organism and environment and that denies the existence of pre-determined, domain-specific facilities or capabilities." (p. 95)

Emergence was at the centre of a 2006 special issue of *Applied Linguistics*, entitled 'Language Emergence: Implications for Applied Linguistics'. In the introduction, the editors Nick Ellis and Diane Larsen-Freeman outline their belief "that our interests in language can better be furthered when it is conceived of as the emergent properties of a multi-agent, complex, dynamic, adaptive system, a conception that usefully conflates a property theory [focusing on language representation and competence] with a transition theory [focusing on language acquisition and use]." (p. 558)

This focus on the process of learning rather than the outcome is also shared by van Lier (2010) who states that an ecological approach allows us to better understand “the learning process, the actions and activities of teachers and learners, the multilayered nature of interaction and language use, in all their complexity and as a network of interdependencies among all the elements in the setting, not only at the social level, but also at the physical and symbolic level.” (p. 3)

## **Complex dynamic systems theory**

One theory that is particularly suitable for examining ecological aspects of language learning and that has increasingly been drawn upon over the past couple of decades – first in applied linguistics more generally and then more recently in computer-assisted language learning (CALL) – is complex dynamic systems theory (CDST) – also referred to as complex systems theory, complexity theory, or dynamic systems theory.

In their programmatic publication entitled ‘A Transdisciplinary Framework for SLA in a Multilingual World’ the Douglas Fir Group (2016) – made up of fifteen key North American scholars in applied linguistics – argue for an epistemological expansion of research in applied linguistics. Going beyond the cognitive approaches common in second language acquisition research, they describe language use and learning as ‘emergent, dynamic, unpredictable, open ended, and intersubjectively negotiated’. Their framework is guided by the following ten themes which reflect this:

- Language competencies are complex, dynamic, and holistic
- Language learning is semiotic learning
- Language learning is situated and attentionally and socially gated
- Language learning is multimodal, embodied, and mediated
- Variability and change are at the heart of language learning
- Literacy and instruction mediate language learning
- Language learning is identity work

- Agency and transformative power are means and goals for language learning
- Ideologies permeate all levels
- Emotion and affect matter at all levels

The theories underpinning their framework as outlined in the publication include – amongst others – complexity and dynamic systems theory (Larsen-Freeman), ecological and sociocognitive approaches (Atkinson) as well as sociocultural theory (Johnson, Lantolf, Negueruela, Swain). I have proposed that these theories also lend themselves to trying to understand what the impact of the digital technologies has been on language learning and teaching (see Hampel 2019).

Most readers will be familiar with sociocultural theory, but may wonder what exactly a complex system is. As Mitchell and Newman (2002, p. 1) explain, it is a group or organization where the different parts interact with one another, manifesting large-scale behaviours in ways that are not easily predictable or easy to model. These collective effects are called ‘emergent’. Systems that are complex have distinct properties that arise from these relationships, such as nonlinearity, emergence, spontaneous order, adaptation, and feedback loops. Yet systems theory was not developed to explore languages and language learning but in the context of trying to understand natural phenomena, such as the global climate, economies, immune systems, ant colonies, and other ecosystems – from individual organisms to entire species.

So let us consider the origins of complex systems theory and then chart its development across various academic subject areas. According to Capra and Luisi (2014), complex systems theory has its roots in the thinking of Leonardo da Vinci, who ‘developed a new empirical approach – a science of organic forms, of qualities, of processes of transformation’ (p. 7). However, in the 16<sup>th</sup> and 17<sup>th</sup> century the discoveries made in physics and astronomy by scientists such as Nicolaus Copernicus, Johannes Kepler, Galileo Galilei, Francis Bacon, René Descartes and Isaac Newton led to this organic and holistic approach being replaced by a more mechanistic worldview. In turn, this Cartesian worldview was queried in the late 18<sup>th</sup> and early 19<sup>th</sup> century, with Romanticism understanding nature as “‘one great harmonious whole,’” which also impacted on some scientists to ‘extend their search for wholeness to the entire planet and see the Earth as an integrated whole, a living being.’ (Capra & Luisi 2014: 9).

The first half of the 20th century then saw the introduction of the concept of the ecosystem and the development of systems theories, with the sciences (especially biology, psychology and ecology) in the 1940s reacting against the Cartesian paradigm of the world as a machine to account for natural occurrences which were unpredictable and difficult to explain using more traditional scientific approaches. According to the systems view, an organism, or living system, is an integrated whole whose essential properties cannot be reduced to those of its parts. Instead, they arise from the interactions and relationships between the parts.

Systems theory was then taken up by researchers in engineering and management studies before being picked up again in biology in the 1960s and 70s under the label 'complexity theory', with researchers arguing against reductionism and determinism. As Mazzocchi (2008) points out, '[w]ithin this framework, a single cause can produce multiple and unpredictable effects and even small fluctuations can have unexpected consequences. Linear casual explanations—that conceive reality as a linear succession of elementary events from cause to effect—are therefore possibly unable to describe how complex systems behave' (p. 12).

Adopting a systems perspective in applied linguistics means taking account of not just one aspect of the language learning process but understanding it as a system that 'would encompass the learners comprised of their various nested systems (cognitive, biological, affective, etc.), their teachers, the materials, the spaces they move across, and the places for learning that emerge as they interact with and within these spaces.' (Murray & Lamb 2018: 258) Depending on the discipline and the emphasis, different labels are being used for what are closely related theories. According to Cameron & Larsen-Freeman (2008), in mathematics dynamic systems theory is a more common label. Systems theory focuses on structures, relationships, and interdependence between elements, while complexity theory is more commonly used in organization theory, treating complexity 'as a structural variable that characterizes both organizations and their environments.' (Anderson 1999: 217). Even within

applied linguistics there are several terms with different connotations. Larsen-Freeman and Cameron (2008), for example, use the term ‘complexity theory’ (alongside ‘complex systems’). And more recently, the term ‘complex dynamic systems theory’ (CDST) has been recommended by de Bot (2017).

A related theory is chaos theory – which has been used in the natural sciences to explain the transition from order to turbulence (or ‘chaos’), due to what has been called ‘sensitivity to initial conditions’ (the so-called butterfly effect), where a small change in one state of a deterministic nonlinear system can result in large differences in a later state. Thus, ‘chaos should be understood as deterministic, organized, structured, and long-term unpredictable and to illustrate what is meant with the example of meteorology, quoting Lorenz and his *butterfly effect*.’ (Letellier, Olsen, L.F. & Mangiarotti 2021: 31). In the social sciences, chaos theory has also been drawn on to explore convergence and divergence, stability and instability, evolution and revolution in organizations, determinism and unpredictability (Thiéart & Forgues 1995), thus for example helping to understand how organizations work. While these characteristics seem to be contradictory, chaos theory shows how it is perturbations to system trajectories that can alter the periodicities of trajectories over time, sometimes plunging some systems into chaos.

### **‘A wicked problem’: The ecology of language learning**

So how can a theory that originates in the natural sciences help us understand language learning and teaching? Looking back to the 1970s, Phil Hiver, Ali Al-Hoorie and Diane Larsen-Freeman (2021) point to a distinction made by Horst Rittel and Mel Webber (1973) between the ‘tame’ problems that characterize the hard sciences and the ‘wicked’ problems that plague the social sciences.

Wicked problems [...] are issues in the social realm that “cannot be addressed by assuming, as science does, that they are ‘tame’ or ‘benign’, or definable, separable, and solvable” (Crowley and Head 2017: 541) and, consequently, these problems cannot be understood, analyzed, and dealt with by adopting any one form of positivist

or relativist methods. Wicked problems are diabolical in the sense that they resist all the usual attempts to resolve them. These issues defy easy solutions because they are highly complex, with no consensus understandings or readily apparent resolution; are intricately interconnected with other problems and entrenched across multiple levels of the social world; and, consequently, affect the lives of countless everyday people. (p. 8)

For Hiver, Al-Hoorie and Larsen-Freeman (2021: 8), multilingualism and second language (L2) development are examples of such wicked problems, and they illustrate this by using the example of understanding second language development/acquisition (SLD) 'to meet the challenge of responding to the pressing needs of additional language users, their education, their multilingual and multiliterate development, social integration, and performance across diverse globalized, technologized, and transnational contexts' (Douglas Fir Group 2016: 24). At the same time, they offer a way of approaching such wicked problems, arguing that as a meta-theory or paradigm, CDST is an appropriate approach to help to make sense of them.

Thus complex dynamic systems theory has been used by researchers in applied linguistics over the past couple of decades to try and understand development and change in language and language learning. Focusing on uncertainty and non-linearity, CDST provides 'a more holistic perspective on language and its learning' (Larsen-Freeman 2017: 141) by allowing us to explore systems that are composed of different components which can interact with one another and to examine entities engaged in dynamic processes that are not predictable.

With her 1997 article entitled 'Chaos / complexity science and second language acquisition', Diane Larsen-Freeman was one of the first scholars in applied linguistics to see the possibilities of complex dynamic systems to provide this more holistic view of second language development – rather than trying to understand it in a 'piecemeal, atomized way.' (p. 18). She describes complex dynamic systems as open, adaptive, and complex (p. 16). This means that the components of a complex system 'are both interconnected and



spatially/temporally context dependent', they 'can operate at different nested levels of scale [...] and across timescales' (p. 16). And as she explains, the nonlinear interaction of the components means that patterns arise that could not have been anticipated from the components themselves (Larsen-Freeman 2017). She summarizes the nature of 'complexity' as follows:

What makes a system complex is that its components (elements or agents) are both interconnected and spatially/temporally context dependent (Juarrero, 2000: 26). [...] Complex systems can operate at different nested levels of scale (e.g. from molecules to whole ecologies) and across different timescales (from nanoseconds to supereons or in the case of humans, across a lifespan). (p. 16)

Her understanding of dynamic systems theory as a 'comprehensive theory of second language development' has been shared by others over the years, such as de Bot et al. (2013).

Using CDST to try and understand language itself as a dynamic system was also an early focus in applied linguistics (Ke & Holland 2006; Oudeyer 2006; Ellis & Larsen-Freeman 2006). And Breen had proposed as early as in 1999 that the classroom 'needs to be a dynamic self-organising learning community' – something that was picked up by Burns and Knox (2011) who describe the language classroom as a nested system, bringing together physical, environmental, cognitive and social elements. Lynne Cameron and Diane Larsen-Freeman's 2008 book introduced complexity theory into applied linguistics more generally, showing how spoken interaction and classroom language learning can be seen as two examples of complex systems models. Larsen-Freeman (2012) has also argued for 'complexity as a transdisciplinary theme' (p. 203) in applied linguistics more generally. As she points out, 'it offers a conceptual framework to inform "the way in which we investigate and understand nature and the worlds we live in," including "what Bruno Latour (1993) calls the >>hybrid networks<< of social systems in which we find ourselves enmeshed".' (Larsen-Freeman (2017: 12). And in a position paper prepared in the context of a conference

celebrating the 60th anniversary of the journal *Language Learning*, 'The Five Graces Group' (Beckner et al. 2009) claim that the complex adaptive system approach proposed by them reveals 'many commonalities in many areas of language research, including first and second language acquisition, historical linguistics, psycholinguistics, language evolution, and computational modeling' (p. 2).

Reacting to the growing take-up of complexity theory in applied linguistics, Claire Kramsch (2012) gave a symposium presentation entitled 'Why is everyone so excited about complexity theory in applied linguistics?' In this, she describes the difference between traditional approaches to second language acquisition (SLA) – using the concept of interlanguage to explain development – and a complex systems approach. Rather than moving in a linear way from non-knowledge to knowledge and 'slowly approximating the native speaker, a complex model does not posit an initial and an end state. Instead, it sees learning as creating its own conditions of development in open interaction with its environment, and always susceptible to change' (p. 11). She stresses the relational outlook of complexity theory that challenges individual, competitive performance, and thus also the findings of SLA research achieved through isolating variables and establishing causal relationships. She ends by stating the following: 'Complexity theory as applied to language education reminds us of the complex humanistic goals of language learning and teaching, but at the same time it exhorts us to beware of easy metaphors, that can constrain while claiming to liberate, and close horizons while claiming to open up possibilities.' (p. 21)

Over the past 25 years, the CDST perspective has been used across many areas of research in applied linguistics. Hiver, Al-Hoorie & Evans (2021: 2) list some of these alongside key publications:

language development/acquisition (Lowie et al., 2010; Verspoor et al., 2008),  
language attrition (Schmid et al., 2013), language ecology (Cowley, 2011; Kramsch & Whiteside, 2008), language evolution (Ke & Holland, 2006; Mufwene et al., 2017),  
language policy and planning (Bastardas-Boada, 2013; Larsen-Freeman, 2018),  
language pedagogy (Han, 2020; Levine, 2020), bilingualism and multilingualism

(Herdina & Jessner, 2002), sociolinguistics (Blommaert, 2014), educational linguistics (Hult, 2010), and communication studies (Massip-Bonet et al., 2019).

While most of the work has been done in the area of language development, another key focus area where complex dynamic systems theory has been adopted is language learning motivation, influenced by early publications by, for example, Dörnyei (2009). Dörnyei, MacIntyre and Henry's edited book entitled *Motivational dynamics in language learning* (2014) explores the applications of dynamic systems theory to the research of language learning motivation. Papi and Hiver (2020) use complex dynamic system theory to try and understand the complex motivational development of language learners. And Ushioda (2016) conceptualizes the language learner 'as a complex system comprising a dynamic constellation of cognitive, affective, motivational and behavioural characteristics which are in constant interaction with one another.' (pp. 18-19).

Language anxiety is another area where a complex dynamic systems perspective has been employed, for example by Mahmoodzadeh and Gkonou (2015) who explain the emergence and maintenance of foreign language classroom anxiety, or by Gregersen (2020) who shows how language anxiety is a dynamic individual difference learner variable. Pfenninger's (2022) study also explores individual difference, in the context of emergent bilingual (pre)primary school children. Glenn Levine – in a 2020 monograph in the *Modern Language Journal* (MLJ) entitled *A Human Ecological Language Pedagogy* – draws on CDST to bring together different perspectives in what he calls a 'human ecological language pedagogy' (p. 7). His aim is to identify "a perspective of language teaching and learning that responds to the realities of our highly mobile, globalized, digitized society, a world in which millions of people endeavor to learn new languages and who succeed at it to varying degrees" (p. 9). His views represent the approach by many applied linguists today who 'view language not as an entity but a process, as one sort of meaning-making activity through usage in verbal interaction and texts, a set of mobile semiotic resources rather than a bounded, static body of knowledge.' (p. 11)

In her foreword to this MLJ monograph, Lowie (2020: 5) comments on Levine's contribution, pointing out the following:

Levine identifies Complex Dynamic Systems Theory (CDST) as the optimal metatheoretical framework to account for the interactive constructivist epistemology he proposes. However, different from previous teaching applications that tend to emphasize the similarities between CDST in cognition and the physical world, *A Human Ecological Language Pedagogy* takes a strongly ecological perspective, in which human interaction takes a central position. This signifies that Levine's pedagogy corroborates the commensurability of CDST and Sociocultural Theory. Although both theoretical approaches have shown spin-offs to language teaching, for neither of the theories a fully developed set of pedagogical implications had yet been accomplished. And this is exactly what we find in *A Human Ecological Language Pedagogy*.

Levine ends by stressing that the learner should be "first and foremost an emergent member of what Lave and Wenger (1991) described as a community of practice, with the community in question being in fact multiple and intricate (see also Wenger, 1998)" (101), a community where the learner is as a 'legitimate peripheral participant'.

The following proposition by Larsen-Freeman's (2019) provides a suitable conclusion to this section.

[O]ne way to investigate the agency of language learners is through the transdisciplinarity of Complex Dynamic Systems Theory (CDST), which brings a relational, ecological systems lens to the study of agency. A relational system is "an integrated whole whose essential properties cannot be reduced to those of its parts. They arise from the interactions and relationships between the parts" (Capra & Luisi, 2014, p. 10). What is important for the terms of this discussion, then, is to understand the dynamic relationship between social structure and agency as constituting an

irreducible system, structure and agency [...], all while the space in which the relationship is situated and the time at which it is situated ever changes. (p. 64)

## **Complexity theory and CALL: A theoretical framework for language learning and teaching today**

As the Douglas Fir group (2016: 19) highlight, 'multilingualism is enmeshed in globalization, technologization, and mobility.' The increased use of digital and online technologies has opened up the language classroom to the world (both in terms of bringing second language resources into the classroom and of enabling students to encounter the second language outside the classroom in the wild) – making the 'problem' of language learning as identified above even more 'wicked'.

Various researchers have made a case for the usefulness of complex dynamic systems theory in the context of CALL. Robert Godwin-Jones has been particularly impactful in this area, as reflected in his 'Emergent Technologies' section in the journal *Language Learning & Technology*. This includes a 2018 article entitled "Chasing the butterfly effect: Informal language learning online as a complex system", another in 2020 entitled "Building the porous classroom: An expanded model for blended language learning", and more recently a contribution in the context of 'Evolving technologies for language learning'. In this latest article, he comes to the conclusion that '[t]he image of a porous classroom and Levine's concept of a human ecological approach to SLA point to the dynamism and unpredictability of modern SLA. I argue that this should inform CALL research today.' (Godwin-Jones 2021: 16).

Both Levine (2020) and Godwin-Jones (2021) use the metaphor of the surfer to illustrate that the complex ecological system of the ocean surfer – with its interdependent dynamic of body and environment – parallels the contemporary language learner, especially in the context of online informal language learning.

Successful outcomes are not assured and are dependent on both the individual's background, initiative, and competence, as well as on local conditions. The surfer's

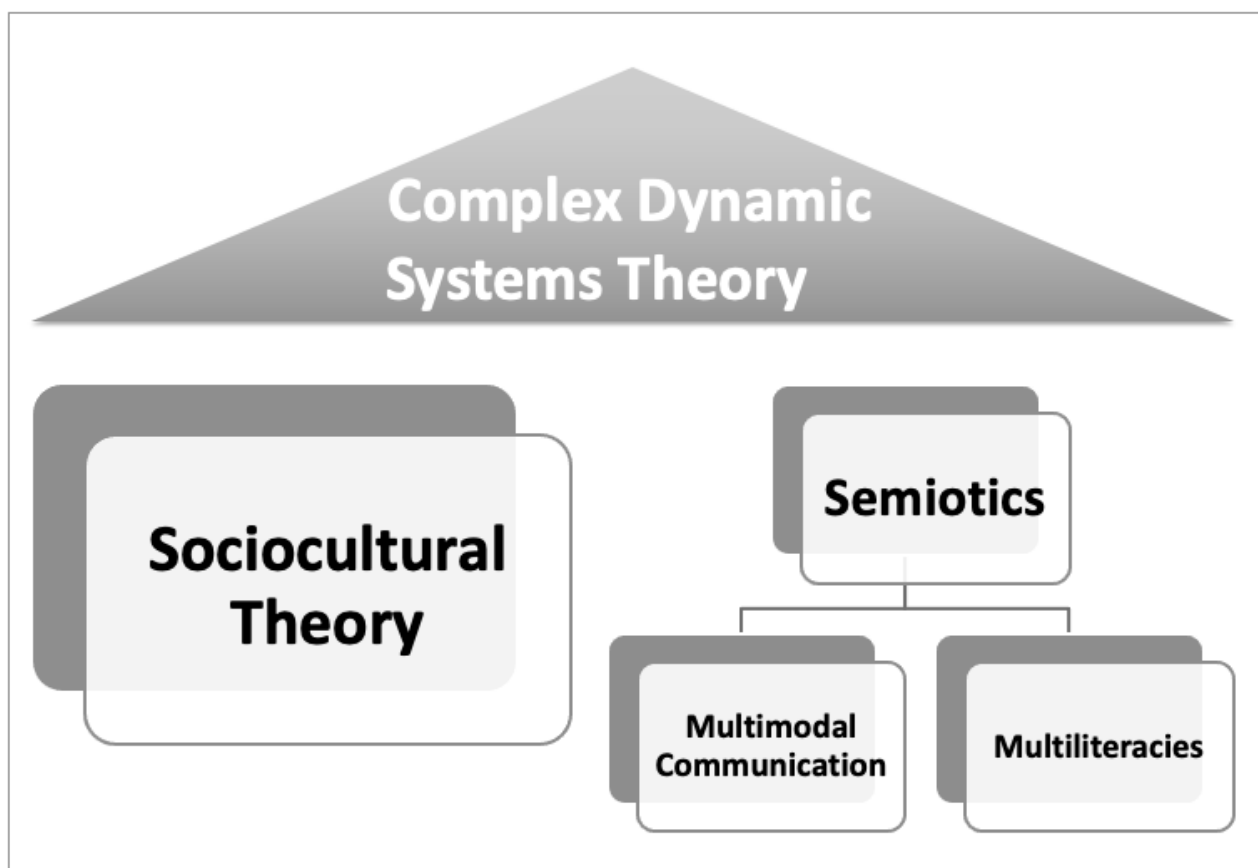
trajectory, like that of the language learner, is susceptible to the kind of initial conditions at hand (of the individual and of the environment), both of which are subject to constant change. Second language (L2) development is a dynamic process, often nonlinear and episodic, making static or linear metaphors of mastery or programmatic progression invalid (Godwin-Jones, 2019c, p. 9). (Godwin-Jones, 2021, p. 14)

So although complexity theory was developed within the natural sciences, it has the potential not just to characterize the natural world but also learning processes – as shown in the previous section. In the case of CALL, CDST allows us to conceptualize it as a dynamic phenomenon that consists of ‘multiple, interconnected variables’ (Godwin-Jones 2018: 8) and that includes learners, teachers, the learning environment (which can be formal, informal or non-formal), and technologies. It thus allows us to examine entities engaged in a dynamic process – such as a group of people with different first languages using a second language while interacting with one another in an online gaming environment, or two language classes with different second languages communicating with each other.

This approach is more appropriate than what Godwin-Jones (2021) calls ‘problematic theories’, which include ‘the accumulation metaphor for learning grammar, the assumed linearity of SLA, and the division between implicit and explicit learning’ (p. 16). And he points ‘to the ecological invalidity of a determinist orientation to cause and effect studies, particularly those based exclusively on results from pre- and post-testing (Godwin-Jones, 2019b)’ (Godwin-Jones 2021: 16) in CALL.

However, in order to take full account of the transformation in how we communicate that the new media have brought about and of the complexity of language learning in the digital age, Hampel (2019) proposes to link complex dynamic systems theory with sociocultural theory and social semiotics (multimodality and multiliteracies) to create a theoretical framework for second language learning and teaching today. Figure 1 shows an updated version of this figure.

Figure 9.1. Theoretical framework for second language learning and teaching today



Thus CDST is used as a metatheory or a heuristic device that allows us to conceptualize the transformative changes that language learning and teaching has undergone. In addition, sociocultural theory provides an understanding of learning as situated in social contexts and the belief that mental functioning is mediated by one's environment, including cultural artifacts, activities and concepts. Ellis and Larsen-Freeman (2006: 572) summarize some key points of sociocultural theory:

- Learning takes place in social contexts
- Speech, speakers, and social relationships are inseparable
- Activity theory emphasizes how individual learning is an emergent, holistic property of a dynamic system comprising many influences, both social, individual, and contextual

- Action provides a context within which the individual and society, mental functioning and sociocultural context can be understood as interrelated moments
- Uttering invokes feedback that is socially provided
- Consciousness itself can be viewed as the end product of socialization
- SLA is also dialectic, involving the learner in a conscious tension between the conflicting forces of their current interlanguage productions and the evidence of feedback [...] that allows socially scaffolded development

Semiotics – more precisely the theory of multimodal communication (see e.g. Kress & Van Leeuwen 2001) alongside the concept of multiliteracies (see e.g. New London Group, 1997; Kalantzis & Cope 2023) – allows us to explore how meaning is created and communicated online. Language learning and language use means being able to combine speaking and listening as well as reading and writing – in different contexts and purposes, and for different audiences. And digital environments in particular allow learners not only to use images and graphical elements to complement the written and spoken word but also to draw on their environment inside and outside the classroom to engage in activities that support the language learning process. Thus language learners today need to be multiliterate – which Kalantzis and Cope (2015) explain as follows:

All meaning-making, across all modes, operates at five levels, with five purposes. We *refer* to things, events, processes and abstractions (Halliday's 'ideational' function). We *dialogue*, with ourselves and others (Halliday's 'interpersonal' function). We *structure* our meanings in ways which are both conventional and always innovative to the extent that every remaking is uniquely modulated (Halliday's 'textual' function). We *situate* our meanings in contexts, or at least find that they are situated by default (what we call a 'contextual' function). And we *intend* when we position and/or encounter meanings in webs of intention or agency (a metafunction we call 'interest').

(p. 19)



Hampel's framework thus tries to do justice to the changes in the ways in which we interact and communicate online. These ways are fundamentally different from making meaning in traditional face-to-face contexts and they have also impacted on our ways of learning and teaching, disrupting the traditional approaches such as the IRF pattern used traditionally in teaching, consisting of teacher initiation, student response and teacher feedback, and encouraging more active meaning-making. The framework also takes into account the new opportunities for communicating multimodally which the digital media offer language learners. And last but not least, it takes account of the greater of the possibilities that the online medium offers for easier engagement with the language 'in the world' (and 'in the wild').

Kalantzis & Cope (2015) point to the variable conventions of meaning in different situations, suggesting that we are faced with a new 'emerging regime of multiliteracies' (p. 15) – especially in relation to the new media. This has been affecting language learning and teaching, with learners as well as teachers needing to adapt to the digital tools and use the new affordances to their advantage. An awareness of these transformational changes helps learners and teachers to make best use of the different communication modes that the digital technologies offer and develop the multiliteracy skills that are required to successfully communicate online, thus benefitting from the opportunities that the new media have introduced and being able to deal with the challenges.

In bringing together complex systems theory alongside sociocultural theory and multiliteracies we acknowledge that language learning is a dynamic process, with ups and downs, and development that is not easily predictable; that it is a social undertaking that takes place in a particular context; and that learners make meaning using a range of semiotic resources. This framework helps us to conceptualize the language classroom (understood in the widest sense as any space where language learning takes place, including online environments) as 'an ecosystem made up of different interacting parts and thus allowing for a focus on the changes that language learning and teaching has undergone over the past couple of decades as a result of the introduction of new technologies.' (Hampel 2019: 8).

## Conclusion

This chapter has tried to show how complex dynamic systems theory with its focus on the ecology of learning can provide a new lens on the transformative changes happening in language learning and teaching today, especially when combined with sociocultural theory (to take account of interaction – a key ingredient in language use and language learning) as well as multimodality and multiliteracies (to account for the changes in communication in today's digital age). It helps us to conceptualize the language classroom (understood in the widest sense as any space where language learning takes place, including online environments) as an ecosystem with particular properties – one that differs from the traditional classroom, with digital technologies affording different approaches to language learning and teaching. The framework recognizes the disruptive effect of the digital media on meaning-making in the traditional language classroom and the transformation that language learning and teaching has undergone, particularly in the context of interaction patterns, communication modes and the ways in which the learner is positioned in relation to the world. What is now needed – as Levine (2020) points out – is for “systemic changes in language pedagogy and much teaching practice” (p. 9) to follow suit.

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