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Complexity Theory and L2 Motivation

Phil Hiver and Mostafa Papi

The core of social science is the study of humans, their behavior, and their interactions. Within this tradition and its scholarly discourse, a complexity-rich reality has been acknowledged as far back as the turn of the twentieth century (Eve, Horsfall, & Lee, 1997). Since the start of the twenty-first century, complexity theory has become a broad foundation for scientific inquiry in the human and social sciences (Capra & Luisi, 2014; Morin, 2001), moving into various domains of applied linguistics (Larsen-Freeman, 2017; Larsen-Freeman & Cameron, 2008). A decade ago, Dörnyei (2008, 2009) proposed the need to rethink individual difference variables in a situated, dynamic manner, and this has led to more comprehensive work on individual differences that reflects the way they interact with the environment through a complex interplay of synchronic and diachronic variation (Dörnyei & Ryan, 2015; Ryan, this volume). In the same year Dörnyei, MacIntyre, and Henry's (2015) landmark Motivational Dynamics anthology definitively put complexity on the L2 motivation research map. This signaled a growing momentum, not so much for a dynamic turn but rather for a complete reorientation to the way in which L2 motivation scholars see, investigate, and intervene in the world—what Schumann in the same volume heralded as a new "epistemological basis for conceptualizing motivation" (p. xv). This has resulted in a new L2 motivation research landscape in which complexity has begun to establish its relevance and explanatory potential (Dörnyei, 2017, this volume).

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Although many instances exist when the human and social sciences have taken their inspiration from developments in other sciences or developed parallel insights independently from those domains (Cilliers, 2005; Horn, 2008; Morin, 2001), applied linguists have questioned the compatibility of complexity theory with the task of conceptualizing and researching the social phenomena most language motivation scholars are concerned with (e.g., Lantolf, 2016). What is remarkable, however, is that in the last three decades, the human and social disciplines have become net contributors to complexity theory's philosophy of science (e.g., in the work of individual scholars such as Morin, Bhaskar, Cilliers, and Overton) and methodology (e.g., through the diverse work of scholars such as Weiner, Byrne, Barabási, and Ragin) (Byrne & Callaghan, 2014). Complexity theory clearly is no longer—if it ever truly was—the domain of the physical and mathematical sciences (Larsen-Freeman, 2017), and over the past few years has become a key player in our own field (Hiver & Larsen-Freeman, 2020). In this chapter, we explore the contribution of complexity theory to conceptual and empirical work on L2 motivation, provide examples of how it has informed theory and practice in our field, and extend our discussion to methodological considerations and the future of L2 motivation research from this dynamic and situated perspective. We turn now to examining the contributions that a foundation in complexity theory has offered for the field of L2 motivation research.

Conceptual Tools and Principles of Complexity

In this section of the chapter, we draw on the treatment of CDST by Larsen-Freeman (2015, 2017) to highlight some of the basic, relevant conceptual tools and principles of complexity for theory and practice in L2 motivation. Although we introduce these in sequence, it is their combined insights that captures the essence of complexity-inspired L2 motivation research (see also Hiver & Al-Hoorie, 2016).

A Way of Thinking

A major contribution of complexity theory (CDST) to theorizing and researching L2 motivation has been its new way of thinking—one that entails reconceptualizing the objects and phenomena of interest in our field to more closely reflect the way they actually work (Larsen-Freeman, 2013, 2015). This new way of thinking provides a set of powerful intellectual concepts and

principles (e.g., time; self-organization) that allow us to theorize and interpret particular phenomena or aspects of L2 motivation in new ways that are grounded in a context-dependent and dynamic view of development (Davis & Sumara, 2006). This has begun to manifest itself explicitly in new strands of motivation research related to multilingualism (Henry, 2017; Ushioda, 2017), long-term motivation (Henry, Davydenko, & Dörnyei, 2015), small group dynamics (Poupore, 2018; Sampson, 2015; see also Fukada, Falout, Fukuda, & Murphey, this volume), learners in contexts (Murphey, Falout, Fukuda, & Fukada, 2014; Sasaki, Kozaki, & Ross, 2017; Yim, Clément, & MacIntyre, this volume), demotivation (Kikuchi, 2017; Thorner & Kikuchi, this volume), and the teacher-learner relationship (Hiver, 2017; Lamb, 2017; see also Kubanyiova, this volume)—to name just a few. However, this contribution also suggests a need for L2 motivation researchers to appropriately revise existing understanding of the field in ways that are compatible with this new way of thinking. One example of this is the realization that L2 motivation can no longer be conceived of exclusively as a conventional, modular independent variable. Scholars championing this new way of thinking have called for an integrative framework "to explain the dynamic development of real people in actual contexts" (Dörnyei, 2017, p. 87). It is possible, even highly likely, that using these conceptual tools will challenge many of our existing assumptions and encourage us to reconsider research and practice in the field of L2 motivation (MacIntyre, Dörnyei, & Henry, 2015). New ways of conceptualizing the domain are likely to suggest new approaches to inquiry and tools for that purpose, and a deliberate rejection of certain other principles and ideas regarding L2 motivation (Ushioda, 2009). We elaborate further on these below.

A Relational Unit

Importantly, complexity invites scholars to think how parts of the whole relate to each other in L2 motivation research (Nolen, Horn, & Ward, 2015). Thus, one tool on offer from a complexity perspective is a distinctive relational unit of analysis—a complex system. This allows us to conceptualize language learning motivation more organically as a relational and soft-assembled system (i.e., constrained more by contextual affordances and task demands) rather than as an often-essentialized artifact (see e.g., MacIntyre & Serroul, 2015). As the world is dynamic, the unit(s) of analysis should be equally dynamic—phenomenologically real complex systems situated in context. Complex

systems (Hiver & Al-Hoorie, 2016) that may form the basis for L2 motivation research:

- consist of a number of elements or components situated in context;
- these components, at least one of which is an agent, interact with each other based on certain principles of interdependence;
- over time, the components change as a result of their interactions with other components;
- the effects of these interactions result in the system exhibiting system-wide and macro level patterns of behavior.

Complex systems in context can be considered the paradigmatic object of interest, and thus, the fundamental unit of analysis in L2 motivation research which adopts this perspective (MacIntyre et al., 2015). It is from the components and their relationships that system behavior emerges, which illustrates the importance of relational units in L2 motivation research (Ushioda, 2009). Motivational outcomes and processes arise from a web of relationships that continually grow, change, and adapt to new situations (see by illustration Example 6.1), underscoring a fundamental quality of L2 motivation, that it is relational in nature (Csizér, Kormos, & Sarkadi, 2010). At the same time, the study of human and social systems always implicates agency, whether this is individual or collective (Al-Hoorie, 2015; Kelso, 2016). This makes it necessary to include within any system's boundaries an agent, or agents, capable of exercising intentional action that contributes causally, though not deterministically, to the system's motivational outcomes and processes of change (see also Mercer, 2012).

Example 6.1 Relational Units of Analysis

A study that illustrates the importance of relational units of analysis in L2 motivation comes from a research project examining regulatory fit effects on task engagement and incidental vocabulary learning by Papi (2016, 2018). Motivational factors interconnected at three levels influenced how 189 ESL learners completed an integrated reading/writing task. The levels in this unit of analysis included (a) the dominant motivational dispositions of the learners (i.e., *promotion-focused*—concerned with growth, accomplishments and gains, or *prevention-focused*—concerned with safety, obligations and losses), (b) the incentive structure of the task (i.e., framed in terms of *gaining points* versus *losing points*), and (c) the regulatory focus of the task (i.e., encouraging creativity and risk-taking versus emphasizing accuracy and attention to detail). A match or mismatch at any of these three levels resulted in qualitative differences in task engagement and vocabulary learning, illustrating that these outcomes were tied to the interdependencies between levels in the unit of analysis.

Dynamic Change and Development

Language learning motivation is now recognized as a dynamic, situated factor characterized by temporal and contextual variation (Dörnyei et al., 2015). Thus, one of the most important changes of adopting a complexity perspective for L2 motivation research has been that time matters (Lemke, 2000). An undeniable advantage of refocusing attention more explicitly on motivational processes than on outcomes and variables, is that it has allowed scholars to take a much more developmental perspective in L2 motivation research (e.g., Henry et al., 2015; Waninge, Dörnyei, & de Bot, 2014). In a complex system where many components and factors interact over time, tiny differences in initial inputs can quickly become overwhelming differences in motivational trajectories (de Bot, 2015). There may in fact be multiple "levels of reality" (Cilliers & Nicolescu, 2012, p. 716) at different timescales that represent individual experiences and processes. Systems' initial conditions and histories have a critical role to play in every system's process of becoming (Verspoor, 2015). This contrasts with the previously implied view of L2 motivation as more of a static and essentialized individual attribute. Thus, a particular added value of a complexity perspective for L2 motivation research and its gift of time is an emphasis on processes of change and development at various timescales (Elman, 2003).

The complex systems that are part of the phenomena scholars would like to investigate in L2 motivation evolve through time, and the reliability of any probabilistic predictions of complex system behavior depends on multiple factors that overlap and interact interdependently, with some factors in the system playing a larger role at certain times but not at others (Overton & Lerner, 2014). However, dynamic change is non-telic in the sense that motivational processes progress through time without a predetermined, fixed goal (Howe & Lewis, 2005). In any case, what might seem to be an end point in L2 motivation or development is likely just one of many stable points in an ongoing and dialogic work in process (de Bot, 2015). This aspect of *nonfinality* means that systems are not defined by progressing towards an endpoint because final states do not exist for system development (Rose, Rouhani, & Fischer, 2013). Complex systems constantly reorganize their internal working parts and adapt themselves to the problems posed by their surroundings (see by illustration Example 6.2), and this sustained adaptation of systems is capable of producing a rich repertoire of L2 motivation behaviors (see e.g., Henry, 2015). It can, of course, be challenging to understand these dynamics or intervene in a system's trajectory of change (e.g., Han & Hiver, 2018). However, adaptive change is the pivotal characteristic of seeing L2 motivation

from a complexity perspective because it allows us to value variation as strongly as states and to think in a connected way about both outcomes and their processes (Larsen-Freeman, 2012, 2013). For this reason, it entails an expansionist perspective for our field which takes into account the realization that variability and change are at the heart of all L2 motivation.

Example 6.2 Dynamic Change & Development

Extending the study described above sheds light on the pervasiveness of dynamic change in L2 motivational phenomena. Papi's (2016) study had multiple steps including, among others, vocabulary tests, reading comprehension, and a writing task. In the first steps of these tasks, promotion-focused individuals were more engaged when the reading task was framed in gain terms (i.e., gaining points by answering reading comprehension questions) and prevention-focused individuals were more engaged when the reading task was framed in loss terms (e.g., losing points for giving wrong answers). However, as the learners transitioned from reading to writing, these motivational dynamics began to change, and the initial patterns of engagement developed in different ways. Prevention learners in the loss condition performed significantly better on the vocabulary test and developed greater engagement in the writing task than prevention learners in the gain condition. By contrast, for the promotion learners the motivational force of the new task dwarfed the motivational effects of task framing; they performed equally well, and better than prevention learners, in both gain and loss conditions. In other words, over time the promotion focus of the writing task upset the match between the two other motivational levels (dispositions and incentive structure) and resulted in asymmetric levels of engagement and learning.

Openness of Systems to Context

Because the thing under investigation is a new relational unit, a major conceptual tool for L2 motivation is the idea that context shapes complex system behavior and its outcomes (Ushioda, 2009). This notion of interdependence between a context, the individuals studied within that context, and the phenomena of interest is not new in applied linguistics (Kramsch, 2008) but has not been part of the mainstream discourse, and as such has only recently come to be discussed more explicitly in relation to L2 motivation (Ushioda, 2015). Extending this and asserting that context is an intrinsic, core part of all motivated thought and action is a significant conceptual shift (Larsen-Freeman, 2013). The main implication of this is that L2 motivation is always situated and thus contextually constrained (e.g., Joe, Hiver, & Al-Hoorie, 2017). This assumption is grounded in the idea that adaptation and development are not based on hard-assembled motivational mechanisms that exist independently of the immediate context which a system is part of, and are not simply activated or brought on-line in each situation the system encounters

(Larsen-Freeman, 2015). Instead, in L2 motivation soft-assembled mechanisms involve a particular adaptation of the system in its environment and are only realized within the immediate context of a situation or task (Mercer, 2016), involving only the tools and structures that are currently available and necessary.

Complex systems' openness to the environment gives rise to context-dependent behaviors (see by illustration Example 6.3) and this means that L2 motivational outcomes and paths of development cannot be understood by decomposing them into analytically discrete elements or variables (Nolen et al., 2015). Any complex system is an open synthesis of many parts interacting with one another and with the larger context in which it is situated. Complex systems in L2 motivation are not only embedded within an environment and interact with these surroundings continuously, but they are also an integral constitutive part of that context (e.g., Csizér et al., 2010). Thus, the environment cannot be seen as merely an additional factor among many for consideration when interpreting motivated L2 behavior. Instead, contextual factors should be seen as actual dimensions of the system itself (Rauthmann, Sherman, & Funder, 2015).

Example 6.3 Openness to Context

Illustrating the importance of context in a study of 287 L2 learners' motivation and feedback-seeking behavior, Papi, Rios, Pelt, and Ozdemir (2019) found that learners' feedback-seeking strategies varied as a function of the setting (i.e., classroom vs. private) and source (i.e., teacher vs. others) of feedback, the context-specific achievement goals learners pursued (mastery-oriented vs. performance-oriented), and their beliefs about the malleability of their language learning intelligence. Whereas learners who endorsed an incremental theory of L2 intelligence (i.e., the belief that language intelligence is malleable) chose mastery-oriented goals which led them to use various feedback-seeking strategies without concern for the ego and self-presentation costs involved, individuals who had an entity theory of L2 intelligence (i.e., the belief that language intelligence is fixed) endorsed performance-oriented goals, which led them to avoid seeking feedback in the classroom (a public context where the ego and self-presentation costs of feedback seeking are perceived to be high) and instead ask their teachers for feedback in private contexts where they perceived the ego and self-presentation costs of feedback seeking to be low.

Self-organized Emergence

Given the right conditions or inputs over time, many things in the human and social world tend to sort themselves out even better than if those involved

had sat down and tried to force a solution (Urry, 2005). This is because systems spontaneously take advantage of upheaval by adaptively restructuring their working parts and connections and settle in a coherent outcome (Larsen-Freeman & Cameron, 2008). Within a complexity frame of reference, the L2 motivation outcomes of interest are often self-organized outcomes, tied to the notion of *attractor states* (Hiver, 2015). Motivational attractors represent pockets of dynamic equilibrium that a system stabilizes into despite the many layers of complexity it may encounter. For example, language learners might come to make sense of their learning experiences through certain routines of action or inaction (see e.g., Chan, Dörnyei, & Henry, 2015), or settle into unproductive learning patterns or other more virtuous psychological outcomes (e.g., Yashima & Arano, 2015). The mechanisms for this are part of self-organization: a process by which higher-level order emerges, without overt engineering, from the local interaction of components and agent(s) in the system (Larsen-Freeman & Cameron, 2008). As with the language learners and their developmental patterns illustrated in the studies cited directly above, complex systems equilibrate through time to display qualitatively distinct motivational patterns that may not have been anticipated by looking at the component parts individually (by illustration see also Example 6.4). The emergent patterns that self-organization leads to in the human and social world are at the very heart of a complexity perspective (Larsen-Freeman, 2013, 2015).

Determining how this spontaneous self-organization takes place is the primary goal of complexity research, and one key mechanism is feedback (i.e., when the system's output loops back as input). From a complexity perspective, feedback from this changing environment influences motivational change in an iterative fashion as systems adapt nonlinearly in response to it (Dörnyei, 2014). Negative feedback, which should not be thought of as undesirable, is the most common type: it feeds into self-organization by restoring equilibrium to the system and bringing its behavior back in line (Byrne & Callaghan, 2014). This cybernetic sense of negative feedback can also be illustrated by the example of a thermostat that is designed to maintain a set temperature by turning off, until the temperature drops sufficiently to trigger the heating on again. Positive feedback, on the other hand, reinforces a system's movement along a developmental pathway that can lock-in a system into path dependence or spread to a system-wide pattern. One illustration of this positive feedback is the example found in patterns of climate change in which elevated temperatures can result in a cascade of runaway effects if left unchecked. Self-organized emergence means that L2 motivation must be conceptualized as relational, developmental, and dynamic rather than essentialized

as a latent attribute individuals possess (MacIntyre et al., 2015). L2 motivation is constructed as a dynamic process within a given context and encompasses the learner's sense of purpose for language learning, entails meaningful action and effortful engagement towards that deliberate goal, and is shaped in the interaction of personal and social dimensions. Thus, the ways in which complex systems in context self-organize through feedback loops in order to maintain their functioning over time has important applications in the way we conceptualize L2 motivation (Waninge et al., 2014).

Example 6.4 Self-organized Emergence

Extending our previous example, the study by Papi et al. (2019), demonstrates how learners' motivational and behavioral patterns emerged from interactions between the local system components in the specific contexts and relationships in which they were situated. Learners with different implicit theories of intelligence and achievement goals adopted different feedback-seeking strategies depending on the perceived costs and values of these behaviors, and their learning behaviors self-organized into particular outcomes. Learners with an entity theory and performance goals pursued a superordinate goal of protecting their own self-esteem by avoiding or ignoring corrective feedback in the public setting of class. Instead, they sought feedback in contexts where the perceived costs were low or chose sources of feedback they could trust would not harm their self-esteem. This study illustrates how shifting beliefs about intelligence can result in learners' self-organizing around qualitatively different goals, and that a change in the belief system can permeate the whole system and result in the emergence of new cognitive, emotional, and behavioral patterns.

What Does Complexity Theory Mean for L2 Motivation Research?

Further contributions from complexity to the study of L2 motivation have been methodological, as an aid to designing programs of research that prioritize adaptive and developmental processes. Using ideas from complexity allows researchers to provide more complex descriptions, analyses, and interpretations of programs, practices, and initiatives (Hiver & Al-Hoorie, 2016). Complexity entails a transdisciplinary approach to inquiry that creates unity beyond disciplinary boundaries, turns more toward a problem-oriented approach, and allows researchers to achieve common scientific goals (Halliday & Burns, 2006). The idea of transdisciplinary research is not without its own set of challenges, and some questions for consideration include these: What does doing impactful L2 motivation research from a complexity perspective

actually entail? Does complexity require L2 motivation researchers to adopt new methodological toolkits, like some from social complexity argue (e.g., Byrne & Callaghan, 2014)? And, how should a transdisciplinary program of empirical research be designed and conducted?

Transdisciplinary Research Designs

Social complexivists have addressed the methodological contribution of complexity in relation to its nature as a meta-theory—a set of coherent principles of reality (i.e., ontological ideas) and principles of knowing (i.e., epistemological ideas) that underpin and contextualize the research designs and methodological choices researchers make (Hiver & Al-Hoorie, 2016; Larsen-Freeman, 2017).

Overton (2015, p. 166) remarks that metatheories such as complexity theory "capture concepts whose scope is broader than any particular theory, and which form the essential conceptual core within which scientific theory and observation function". The very existence of the transdisciplinary intellectual tools and concepts that complexity brings to bear on the problem space of L2 motivation points to complexity's function as a meta-theory capable of informing a broad range of issues and research designs (Overton, 2007). Furthermore, while theories are provisional, and their predictions must constantly be evaluated against observation of new evidence, the complexity *meta*theory pertains to notions of what phenomena, questions, and aspects of social and human inquiry are "meaningful and meaningless, acceptable and unacceptable, central and peripheral" for a field (Overton, 2007, p. 154). As such, complexity has enormous potential to move beyond discipline-specific approaches to address common problems—the very definition of transdisciplinarity.

L2 motivation research, by nature, is *inter*disciplinary because it borrows and combines insights from various subdisciplines in education, language and psychology, and builds bridges between different but complementary theoretical frameworks, allowing each perspective to inform the others (Dörnyei & Ryan, 2015). However, *trans*disciplinarity actually transcends knowledge boundaries and renders dominant disciplinary frames of reference—for just one example whether to self-identify as a quantitative or a qualitative researcher—and methodological silos redundant (Mason, 2008). What transdisciplinary research leaves in place of disciplinary boundaries is a problem-oriented approach to scientific inquiry that creates unity beyond disciplinary perspectives, and the implications of these efforts for L2 motivation research

are far reaching as they orient scholars to achieving common scientific goals. A relevant example of a transdisciplinary research study might be investigating nationwide declining enrollments in foreign languages (American Academy of Arts and Sciences, 2016) and the L2 motivational antecedents and processes associated with this ongoing pattern: this is simultaneously an educational policy and political issue, an economic and financial issue, a teacher education and classroom practice issue, and even a psychodevelopmental issue which requires more than just a coming together of fields to build an understanding of the nature of the problem and potential solutions. The idea in transdisciplinary research is to identify pressing issues that need addressing or questions that demand answers, and then determine the most appropriate methods—typically multimethod—to shed light on possible solutions (Larsen-Freeman, 2017). This is why complexity has such potential to add value to the empirical study of L2 motivation.

Methodological Innovation

While many degrees of freedom exist with regards to the methods of data elicitation and analysis (Hiver & Al-Hoorie, 2020), the appropriacy of methods already prevalent in our field warrant closer scrutiny. Several methods in widespread use (e.g., linear pre-/post- experimental designs) seem poorly-suited to studying L2 motivation in ways that acknowledge its complex and dynamic realities and situate these phenomena firmly in context. Critically examining these is important to advance what Byrne (2009) has called the primary objective of all research: going beyond the particular and uniquely subjective without presuming radical objectivity and generalizability, and still elucidating causation. Recent work has proposed ways in which complexity constrains methodological choices while at the same time encouraging innovation and diversification (Hiver & Al-Hoorie, 2016). Other researchers (de Bot & Larsen-Freeman, 2011; Dörnyei et al., 2015) have laid the groundwork by expanding the methods of data elicitation and analysis available to conduct research in a dynamic vein (e.g., the idiodynamic method, qualitative comparative analysis, retrodictive qualitative modeling). Collectively, this work features individual and group-based methods with emergent, recursive, and iterative designs that are suited to studying dynamic change in context and interconnectedness (Hiver & Al-Hoorie, 2020). Our field is therefore following other social and human disciplines that also seek to understand complexity by routinely drawing on and innovating with existing methods (Jörg, 2011).

While it is true that taking a dynamic and situated perspective of L2 motivation is not a given when using group-level research designs, qualitative individual-level research designs also do not by themselves guarantee a more complex and dynamic perspective for research, particularly if the research design is not inherently connected to or informed by the conceptual framework of complexity (Dörnyei et al., 2015). The value of qualitative case-based methods cannot, of course, be understated (Byrne, 2009; Dörnyei, 2014) as they allow finely-grained observations of L2 motivation over time. However, as others have noted, the selection of methods for complexity-based inquiry in applied linguistics does not suggest an either/or choice, and from complexity's philosophy of science this would not be pragmatic given the range of phenomena that necessitate investigation (Hiver & Al-Hoorie, 2016). Quantitative data elicitation and analyses are equally compatible with dynamic change and interconnectedness as are more qualitative designs (e.g., Molenaar, Lerner, & Newell, 2014; Valsiner, Molenaar, Lyra, & Chaudhary, 2009).

Complexity is a problem-driven, inclusive approach to research that encourages expansion of existing methodological repertoires, and advanced quantitative techniques and methods that value variation, interconnectedness, and change do exist (see e.g., de Bot & Larsen-Freeman, 2011; Valsiner et al., 2009). The potential of quantitative designs for complexity research, of course, extends past the mundane cross-sectional comparisons and measurements of linear relationships into the more compelling areas of identifying underlying structure, accounting for variation at different levels, discerning temporal processes and events, quantifying trends, predicting group membership, applying spatial analysis, and studying networked phenomena nested in contexts. Clearly, we need to expand the field's research methodological repertoire with methods of data elicitation and analysis that are better suited to dynamic and situated phenomena, and sensitive at both the group and individual levels. Some of the methods suggested include various case based methods (e.g., single-case design, qualitative comparative analysis, social network analysis), methods for modeling (e.g., design-based research, agent-based and case-based modeling, retrodictive qualitative modeling, growth-curve modeling), and time-series methods suited to capturing the dynamics of change (e.g., experience sampling, process tracing, Markov Chain Monte Carlo analysis, change-point analysis, event history analysis). Effects and outcomes in L2 motivation cannot be attributed to single, proximate interventions because each individual factor may trigger, influence or even counteract others (see e.g., Papi, 2018). We need a new way of doing things.

Future Contributions to L2 Motivation Research

A conventional, componential way of researching and intervening in the problem space of L2 motivation may be compelling in its simplicity and apparent coherence, but it does not lend itself to dealing with complex effects or situations where results and outcomes are multi-determined—a hallmark of how the human, social world functions. The majority of phenomena of interest in the field of L2 motivation are multi-determined, with diffuse and system-level antecedents of change and causality (MacIntyre et al., 2015). This underscores the importance of using a more situated and dynamic lens in research designs, focusing on wholes and relationships in L2 motivation.

Failing to account for the dependence of a system's behavior on both its current and past environment, the time-scale of change, the context, and the crucial question of agency in explaining development or outcomes can be seen as "fundamental errors" (Byrne & Callaghan, 2014, p. 258) in L2 motivation research. Complexity turns our attention in L2 motivation research toward developing a different logic of explanation—one that is *complex* (i.e., multivariate, multi-level, and path-dependent) and *dynamic* (i.e., involving contingent, co-adaptive processes that are non-proportional) (Byrne & Uprichard, 2012). On the upside, however, actual L2 motivational phenomena involve many different elements and influences, all of which may be acting together at the same time (Dörnyei et al., 2015), which is why this lens allows for a much more ecologically valid way of enacting change. To round off our chapter we propose several guiding principles for doing L2 motivation research in ways that correspond with the conceptual tools and principles outlined earlier.

Focus on relations between open systems in context: If systems are the fundamental unit of analysis in L2 motivation research and represent relational building blocks for dynamic and situated outcomes, identifying the key interactions that shape particular outcomes of L2 motivation is a crucial first step for research that adopts this perspective (Larsen-Freeman, 2016; Mercer, 2016). Establishing these relations and the contribution of contexts to L2 motivation is a necessary step to doing research that is both meaningful and powerful from a complexity perspective. To focus on relations between open systems in context, L2 motivation research could take a problem-based approach to the research, as we have outlined earlier, and identify central knowledge gaps or issues in the field. This is also important in order to adopt designs that go beyond measuring discrete elements or variables in L2 motivation research (MacIntyre et al., 2015), something done in other disciplines

through various design-based methods (e.g., DBIR), as well as set-theoretic (e.g., QCA) and network approaches (e.g., social network analysis). There are likely to be a handful of central relational links in operation that can offer insight into the workings of the system and inform actual adjustments that need to be made. Relational links can loop in bi-directional cycles where reciprocal and recursive flows of causes and effects add another dimension to how systems come to be what they are, or come to behave as they do. There may also be various peripheral—and in some instances even hidden—relations between the system and its context that may have an impact on, and in turn are impacted by, the outcome. Deciphering these cycles is likely to result in revolutionary ways of thinking about engineering outcomes in L2 motivation research (e.g., Henry et al., 2015). Another productive avenue for doing L2 motivation research in this way would be to begin with what Larsen-Freeman (2017), citing the work of Richard Lewontin, has called "functional wholes" that, instead of drawing arbitrary boundaries for systems or units of analysis, are concerned first and foremost with explaining phenomena and that any parts, processes, or boundaries that are examined in the research design depend on what is being explained.

Take time and change into account: Many scholars have recognized the need for more intervention-based research in L2 motivation (e.g., Lamb, 2017). However, particularly in the complex and multilayered settings where L2 motivational phenomena are situated, the point of departure for effecting change may not always be what it appears to be (Larsen-Freeman, 2012, 2016). A system's previous history provides the initial timeframe which is necessary to begin thinking about processes and mechanisms for system intervention. Time and change, thus, contribute to an expanding picture of how effects can be configured to impact L2 learners' motivation (e.g., Papi, 2016, 2018; Park & Hiver, 2017). Outcomes, too, such as particular learning behaviors may not immediately reveal their underlying cause if the source of that outcome or behavior is a process whose sustained effect had a much earlier inception. This is reflected in behavior or programs which appear to have no immediate effect because the antecedents require a period of incubation before the effect unfolds (Morrison, 2008). Motivational interventions may not always produce the same outcome simply because much of motivational practice is about doing the right thing in the right way and at the right time in response to problems posed by particular people in particular places on particular occasions (Davis & Sumara, 2006). Designing effective, scalable, and sustainable policies and programs must hinge on contingent, threshold effects to improve L2 learners' motivation which build up over time until they cascade into one or another outcome. The takeaway from accounting for time

and change in research and practice that intends to develop and support learner motivation is that it should be iterative and premised on adaptive improvement.

Examine networks of L2 motivation and higher-order, emergent outcomes: In addition to prioritizing a situated and dynamic view of individual L2 motivation, complexity allows researchers to engage in level-jumping and examine how the situational aspects of language learning encourage prosocial and collaborative accomplishments in classroom settings. Group processes are a vibrant domain of social psychology, but since earlier work relating this to motivation in L2 learning (e.g., Dörnyei & Malderez, 1997; Dörnyei & Murphey, 2003; Ehrman & Dörnyei, 1998) very little scholarship has materialized on this important dimension of L2 motivation. Particularly at superordinate levels in group processes and interpersonal dynamics, individual language learners are motivated within a higher-order collective if they identify with others and share similar values or L2 learning goals. Taking the network of interactions between individuals in context (i.e., the relational qualities of the system) as the conceptual unit of analysis (Mercer, 2015) will allow L2 motivation scholars to juxtapose individual and collective motivation—the kind that often characterizes commitment to L2 learning in teams or the dynamic group processes in L2 learning institutions.

Ultimately, complexity's value in informing research and theorizing in L2 motivation is that it transcends a deterministic philosophy of science and counteracts the philosophy that causal mechanisms exist and operate independent of other properties or relationships. Thus, from a complexity perspective, L2 motivation research is concerned explicitly with (a) examining agentic systems in contexts and investigating the relational links that bring these systems to life; (b) taking into account time and dynamic change in system development and behavior; and (c) understanding and capturing the adaptive self-organization that results in salient system outcomes in the realm of L2 motivation.

Conclusion

We began this chapter by considering how this framework encourages scholars to view the world and its phenomena and detailing how complexity theory has been used by other disciplines. Then, by extending the recent work of Larsen-Freeman (2015, 2017), we explored some of the key intellectual ideas and theoretical tools that a complexity perspective offers specifically for the field of L2 motivation. Finally, we looked at the future of L2 motivation

research from within this conceptual framework to establish the ways in which complexity theory might inform transdisciplinary research in the discipline. Our position in this chapter has been that complexity not only enriches current understanding of the L2 motivation field, but it also has the potential to provide new empirical answers to long-standing questions.

It is clear that there is no singular perspective or framework that works as a solution to understanding all the complexities of our field (Ortega, 2012, 2013). However, there is an increasing intellectual reorientation in L2 motivation research to embrace complexity, rather than reduce or ignore it, because complexity thinking reflects some of the features that many applied linguists who study L2 motivation already recognize intuitively from our practice. It is also consistent with many assumptions and empirical findings in applied linguistics research more broadly (Larsen-Freeman, 2017). The most exciting contribution of complexity is that it provides a truer perspective for looking at the problem space of L2 motivation, and this can empower us to engage with and acknowledge complexity without the fear of failing to meet an idealized, neat conception of what the discipline should be or should look like. It is, therefore, a conceptual framework well suited to advancing an ambitious agenda for future L2 motivation research (MacIntyre et al., 2015).

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