MANAGERIAL AND DECISION ECONOMICS
Manage. Decis. Econ. **33**: 335–354 (2012)
Published online 1 June 2012 in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/mde.2552

The Dynamics of Emergence: Cognition and Cohesion in Work Teams

Steve W. J. Kozlowski[a,*] and Georgia T. Chao[b]

[a]*Department of Psychology, Michigan State University, East Lansing, MI, USA*
[b]*Department of Management, Michigan State University, East Lansing, MI, USA*

Emergence as a multilevel process has received limited research attention in the micro–meso disciplines of organizational science. Our intent is to explain the conceptual underpinnings of emergence and to advance a more dynamic, process-oriented conceptualization. We discuss emergence as a bottom-up, multilevel process and focus attention on three neglected issues: (a) emergence is dynamic, (b) manifests in different idealized forms, and (c) can vary in form over time. We consider two core phenomena in work teams—cognition and cohesion—to illustrate how this dynamic and multifaceted perspective on emergence can advance theory development and new research directions. Copyright © 2012 John Wiley & Sons, Ltd.

Some of the most engaging and perplexing natural phenomena are those in which highly structured collective behavior emerges over time from the interaction of simple subsystems (Crutchfield, 1994, p. 516).

The aforementioned quote encapsulates the key aspects of emergence as a *process by which lower level system elements interact and through those dynamics create phenomena that manifest at a higher level of the system*. The focus of this article is on how emergence is conceptualized from a multilevel theory (MLT) perspective (Kozlowski and Klein, 2000), how it is typically researched in the micro and meso management-related disciplines of organizational science,[1] and how we believe that theory and research on emergent phenomena should advance. Over the last decade, MLT has shifted from a peripheral interest in micro–meso organizational behavior to a well-developed theoretical perspective with an associated set of research methods and analytical tools that have a pervasive and growing influence in the literature (Kozlowski, 2012a). Although the conception of organizations as nested hierarchical systems has a long tradition in organizational behavior, for most of the 20th century the treatment was largely metaphorical rather than theoretical and empirical (Kozlowski and Klein, 2000). The 'organizational system' has been sliced into disconnected levels of inquiry, associated with distinct disciplines at different levels, and examined with different assumptions and methodological perspectives (Roberts *et al*., 1978). As a meta-theoretical framework, MLT has changed that, facilitating movement toward an integrated understanding of the interplay among the micro, meso, and macro levels of organizational systems.[2]

There are two fundamental systems processes that cut across levels of the organizational system in MLT: (1) top-down *contextual effects* that constrain and shape lower level phenomena (constructs and processes) and (2) bottom-up *emergent processes* at the lower level that combine, coalesce, and manifest as collective phenomena (Rousseau, 1985; Kozlowski and Klein, 2000). Early organizational

*Correspondence to: Department of Psychology, Michigan State University, East Lansing, MI, USA. E-mail: stevekoz@msu.edu

system theorists recognized the duality of structure and process as reciprocal forces such that interaction processes stabilize over time and emerge to form structures that then shape subsequent processes (e.g., Allport, 1954; Katz and Kahn, 1966). In that respect, contextual effects and emergence are related, although we will primarily focus our discussion on emergence. Although both contextual effects and emergence are fundamental for understanding behavior in organizational systems, most research has focused on top-down, contextual effects. Emergent phenomena have generated much less direct theoretical and research attention. When emergence is considered, it has typically been assumed as a process, rather than examined directly, and it has been measured in a static, rather than dynamic fashion. Moreover, emergence has tended to be considered in a limited form (i.e., convergent, homogeneous, *composition* phenomena) even though it can manifest in other forms (i.e., divergent, heterogeneous, *compilation* phenomena).

The purpose of this article is to advance a more dynamic, multifaceted appreciation of emergence in organizational behavior. We provide a meta-theoretical perspective on emergence and its typical treatment in the organizational behavior research. To advance theory and research on emergence, we focus our discussion on teams; they are meso level—at the juncture of micro and macro level influences. The meso level is subject to macro contextual influences that shape the emergence of micro level phenomena to the team level (Hackman, 2003). Thus, the meso level is well situated for theoretical and empirical inquiry on emergence; however, the issues we discuss generalize readily to other ‘bracketed’ levels of interest.

We begin with a meta-theoretical perspective that classifies how emergent phenomena are researched in organizational science. We use this classification to conclude that most organizational behavior research on emergence is static and indirect. We elaborate this further by discussing the assumptions, conceptual underpinnings, and ways that emergence is currently assessed and represented in organizational behavior research. Considering emergence as a *process* and the *dynamic patterns* of how phenomena emerge, we conclude that emergence is not directly assessed, it is represented (i.e., measured) as static, and it is conceptualized in a limited way. We then focus on two emergent team phenomena—team cognition and cohesion—to illustrate how a more *dynamic perspective on emergence as a process* yields new areas of inquiry. This discussion centers on three issues—(a) emergence is a dynamic process; (b) it manifests in different ideal forms; and (c) the forms or patterns of emergent phenomena can vary—that need to be addressed to advance theory development and research.

EMERGENCE IN ORGANIZATIONAL SCIENCE

A Meta-Theoretical Framework

Organizational science is an exceptionally broad domain of scholarship that encompasses a multitude of academic disciplines, different levels of focus, and different methods and assumptions about the best way to study emergent phenomena in organizations. We acknowledge at the onset that any effort to classify these diverse treatments—of necessity—will gloss over important details. Nonetheless, we believe it is useful to have a meta-theoretical understanding of differing approaches so as to clearly position the specific contribution we intend with this article.

Our meta-theoretical framework is shown in Figure 1 and is comprised of two orthogonal dimensions: investigation and methodology. One dimension pertains to the way that emergent phenomena are investigated; whether emergence as a process is examined directly or whether it is indirect. A direct investigation involves some form of data collection that is linked to the process and can explicitly capture changes in the process of emergence over time. An indirect investigation collects data that are used to make an inference about the process of emergence after the fact, but the process is implicit and assumed.

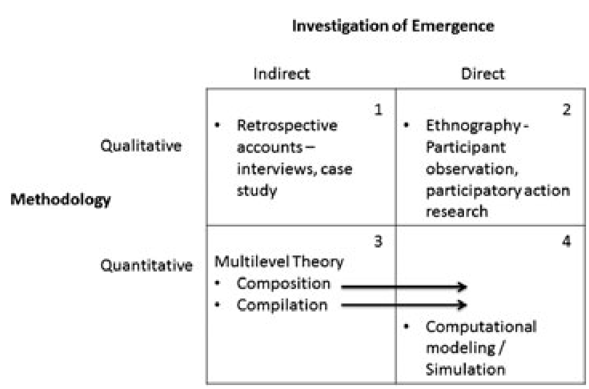


Figure 1. Meta-theoretical framework for studying emergence in organizational science.

DOI: 10.1002/mde

The other dimension distinguishes whether the research approach is qualitative or quantitative. Qualitative research tends to be case-based and is represented by a variety of specific techniques (e.g., narratives, interviews, artifacts, ethnography, participant observation) used to develop a holistic understanding of an emergent phenomenon. Description is rich and interpretive. Such research is valuable for theory building, but replication and generalization tend to be challenges. Quantitative research samples multiple observations with a goal of measurement precision, hypothesis testing, replication, and generalization. Such research is valuable for theory and model evaluation. Because of the attention to measurement precision, which can limit how well a phenomenon is captured, gaining an integrated and holistic understanding of emergence can be challenging.

To illustrate how this meta-theoretical model helps to classify different approaches to the study of emergence, we have highlighted some exemplars in the quadrants of Figure 1. In quadrant 1, retrospective accounts from interviews or case studies of past events represent qualitative-indirect approaches for studying emergence. Stewart (2005) presents a variety of stories to illustrate the emergence of a culture, or *cultural poesis*. These stories are accounts of different people in a variety of contexts, each a snapshot of a culture. What 'emerges' from these stories is shaped by a researcher's story selection and writing as well as the reader's interpretation and sensemaking (Van Maanen, 2010).

In quadrant 2, participant observation and participatory action research represent qualitative-direct approaches for studying emergence. With these methods, researchers live within a focal social system, actively participating in, changing, and observing that culture directly (Kemmis and McTaggart, 2005). Limits to ethnography include the interpretive frames that researchers use to determine what is relevant and how it is described (Van Maanen, 2011). Personal characteristics and work habits can influence access to a phenomenon and the perceptions of what emerges and how it does so. Thus, limitations of qualitative data may pose practical challenges to investigations where the process of emergence is the focal interest.

As we will elaborate in detail in the following section, extant research in organizational behavior based on MLT (i.e., composition and compilation) represents a quantitative-indirect approach—quadrant 3. Emergence as a process is inferred and is treated in a static and limited way. Finally, in quadrant 4, computational modeling and/or agent-based simulation represents quantitative-direct approaches to studying emergence (Miller and Page, 2007). Reynold's (1987) 'boids' simulation of bird flocking is a good example of how a complex, system level phenomenon can emerge from bottom-up, dynamic interactions among individual agents. The individual agents or boids are represented by computational code that optimizes three rules: (a) separation—move away from other boids, (b) alignment—follow the average direction of the flock, and (c)cohesion—move to the flock center. As each agent maximizes its individual set of rules *in dynamic interaction with other agents*, collective flock behavior emerges (Figure 16.7; Flake, 1998). The boids simulation illustrates how a group-level phenomenon emerges from dynamic individual interaction. Analogous phenomena emerge in work teams such as cognition and cohesion; individual 'agents', each attempting to maximize a set of 'rules,' in dynamic interaction with other agents (maximizing similar rules) create complex, emergent, collective behavior.

Implications

Qualitative and quantitative methodologies represent fundamentally different approaches for the study of psychological, social, and organizational phenomena with different strengths and weaknesses. We appreciate the value of qualitative research and utilize qualitative observations in our own theory building. Right now, qualitative research is the only approach that attempts direct assessment of emergence using human actors. However, in qualitative research, the underlying mechanisms of emergence as a dynamic process are not subject to precise scrutiny. One must rely on the interpretation of the investigator. Agent-based simulations can provide precision in the complexity by which individual elements interact *dynamically over time* to create emergent phenomena, but the actors are contrived. Extant research in organizational behavior that seeks to study emergence does so indirectly. Our goal is to push that research into quadrant 4, to study emergence directly as a dynamic process. To do so, it is useful to understand the underpinnings of MLT and current approaches utilized to study emergence in organizational behavior research. Then we will describe how that research can be pushed to directly examine emergence as a dynamic process with human actors, we will highlight some examples from our research, and we will suggest other possibilities for advancing research on emergence.

DOI: 10.1002/mde

EMERGENCE IN ORGANIZATIONAL BEHAVIOR

A phenomenon is emergent when it originates in the cognition, affect, behaviors, or other characteristics of individuals, is amplified by their interactions, and manifests as a higher level, collective phenomenon (Kozlowski and Klein, 2000, p. 55).

Underlying Assumptions

Kozlowski and Klein (2000) distilled a half century of systems theory and research in organizational behavior to develop a set of theoretical and measurement principles to advance MLT research. Before delving into the fundamentals, it is useful to make explicit some assumptions that underlie how micro–meso organizational behavior views emergent phenomena. It is important to acknowledge these considerations because they exert a potent influence on micro–meso conceptualizations of emergence and because they are not typical considerations for macro/economic approaches. Making fundamental assumptions explicit is a critical step in bridging disciplinary divides (Molloy *et al*., 2011).

As highlighted in the aforementioned quote, the emergent phenomena of interest frequently have their origin in individual cognition, affect, behavior, and other psychological characteristics. Most of these psychological factors originate as latent constructs (e.g., cognitive ability, personality) that cannot be directly observed and, instead, are inferred from manifest measures (e.g., cognitive ability test, personality inventory, attitude assessment). Thus, considerable attention is devoted to establishing the *construct validity* of the manifest measure as an indicator of the latent construct (Roberts *et al*., 1978). That is, we need to know that the measure captures the latent construct of interest well and is not merely a weak proxy that is construct-deficient and also contaminated with superfluous information.

That concern for construct validity carries over to constructs that emerge from the individual level but manifest at the team (or higher) levels (e.g., team cognition, team personality, team cohesion). The primary implications of this concern center on (a) how data measured at the lower, individual level are aggregated to represent a phenomenon at the higher, unit level (e.g., sum, mean, other aggregate) and (b) whether the aggregate is treated as an analogous *construct* (i.e., a construct that is isomorphic or parallel in meaning to its individual level origin; e.g., a shared team personality) or as a *descriptive characteristic* of the higher level unit (i.e., the mean of individual characteristics; e.g., average individual personality). In micro–meso organizational behavior, there is a distinct preference for constructs over descriptive characteristics, because the *meaning* of the descriptive characteristic at the higher level is ambiguous. Other disciplines such as epidemiology, organizational strategy, and economics do not generally share this concern. As a result, many macro disciplines regard mean or sum-based aggregates of lower level phenomena as meaningful (e.g., consumer discretionary spending), whereas micro–meso disciplines would regard them as descriptive characteristics unless there is explicit attention to establishing the construct validity of the aggregate (Boyd *et al*., 2005). When those aggregates are based on human behavior, the lack of attention to construct validity can be a problem for interpretation.

There is, of course, an advantage to this concern about construct validity that bears on inference. It is well known that correlations between aggregated indicators are inflated relative to correlations of the characteristics at the lower level (Thorndike, 1939; Robinson, 1950). Thus, one cannot generalize from aggregated relationships to the lower level without risking an ecological fallacy (Rousseau, 1985) and, if the aggregated characteristics lack construct validity, meaningful inferences at the higher level are challenged (Kozlowski and Klein, 2000). By ensuring that aggregated representations of emergents are construct-valid, the interplay across levels and inferences appropriate to each level can be drawn.

Conceptual Underpinnings

Emergent phenomena in organizations (a) originate from lower level elements and interaction processes, (b) are constrained by higher level structures, and (c) are variable in the form by which the emergent phenomenon manifests (Kozlowski and Klein, 2000). As processes, emergent phenomena originate bottom-up and are formed through dynamic interactions among individuals (or whatever units are relevant at the point of origin). The nature of the interaction process is shaped and constrained by higher level contextual factors (e.g., structure, culture, leadership, workflow) operative in the unit. Different interaction process dynamics and constraints shape the way that phenomena emerge and manifest. Thus, the way that emergent phenomena manifest is not universal in form. *Composition* forms are homogeneous, linear, and convergent, whereas *compilation* forms are heterogeneous, nonlinear, and divergent. The same elemental characteristics can manifest as different emergent forms depending on

DOI: 10.1002/mde

interaction processes and contextual contingencies. This has obvious implications for how emergent phenomena should be conceptualized, investigated, and represented.

Bottom-up, dynamic, and interactive. The underpinnings of emergence have been discussed in the biological, social, and physical sciences for decades and are drawn from earlier general systems theory treatments (e.g., Allport, 1954; Boulding, 1956; Simon, 1973) and, more recently, complexity theory (e.g., Nicolis and Prigogine, 1989; Arthur, 1994; Gell-Mann, 1994; Miller and Page, 2007). With respect to the emergence of psychological and social phenomena in organizations, people perceive and interpret contextual stimuli according to their individual differences (e.g., cognitive ability, personality, values). They interact, communicate, and exchange their perceptions. They attempt to make sense of their situation and to maximize psychological gains on those aspects of the situation that are important to them. These individual interactions within social units (e.g., teams, groups) have the potential to create shared perceptions that coalesce around a common understanding (i.e., homogeneous, *composition emergence*), distinctly different points of view that fragment the group (i.e., heterogeneous, *compilation emergence*), or very different interpretations that vary across all the perceivers (i.e., no emergence, an individual property).

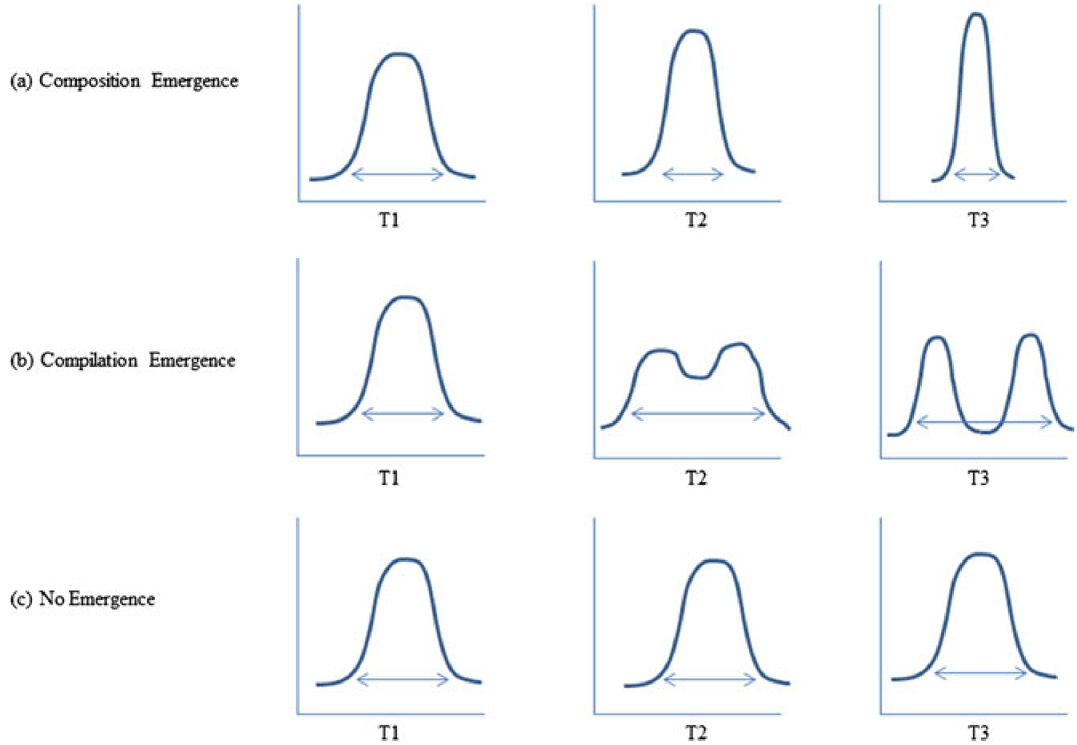
Figure 2 illustrates these forms of emergence. For example, Figure 2(a) shows composition emergence as a series of distribution curves that exhibit a convergence of perceptions over time as individuals share viewpoints and implicitly agree on a shared understanding. Within-unit variance becomes more restricted, signifying convergence, over time. Figure 2(b) illustrates a variance form of compilation emergence. The distribution curves begin with a normal dispersion pattern, but grow increasingly bimodal as individuals interact and become polarized in their viewpoints over time. Figure 2(c) shows a normal distribution of perceptions that are not influenced by interactions and exchange; they do not emerge.

Shaped and constrained by the context. Organizations are 'strong' situations in which the press of contextual forces such as structure, leadership, and workflow systems exert powerful effects that direct, shape, and constrain perceptions and behavior. Thus, in organizations, the nature of emergence is not just based on the 'rules' or the priorities that individuals attempt to maximize, it is also powerfully shaped by contextual contingencies. For example, as hierarchical systems, the structure of organizations sets unit boundaries. People tend to interact more intensely within such proximal units than they do with individuals outside the unit (Indik, 1968; Simon, 1973). Leaders filter and shape information and its flow within units, thereby influencing perceptions (Kozlowski and Doherty, 1989). Formal unit workflows determine patterns of interaction and exchange (Steiner, 1972). In addition, there are also potent informal processes that can shape emergence such as socialization and sensemaking (Chao, 2012). Although these powerful contextual forces are often conceptualized as shaping convergent emergent forms, contextual factors can also yield divergent forms of emergence.

Varied in form. Composition (homogeneous) and compilation (heterogeneous) forms of emergence can be conceptualized as idealized endpoints of a continuum of different types of emergence (Kozlowski and Klein, 2000). Composition emergence is relevant to phenomena that arise via convergent interaction dynamics such that the same elemental content (i.e., perception, cognition, affect) becomes shared in common across all members of a unit. Such constructs are isomorphic. They are essentially the same construct, conveying the same meaning at the individual and unit levels. They are typically measured with the same scale items, but with different referents [i.e., individual (I perceive) versus unit (we perceive); Chan, 1998]. Composition constructs are structurally (i.e., parallel elemental content) and functionally equivalent (i.e., parallel roles in a model) at two or more levels of analysis (Morgeson and Hofmann, 1999; Kozlowski and Klein, 2000). For example, a type of team knowledge—a team mental model—is theorized to develop through team interaction and learning (Cannon-Bowers *et al*., 1993). A team mental model represents knowledge held in common that enables members to anticipate and coordinate action. A team mental model emerges as a composition construct; the same elemental content is shared (i.e., isomorphic) among team members.

Compilation emergence is relevant to phenomena that arise via divergent interaction dynamics such that distinctly different elemental content integrates across unit members to form a pattern or configuration. This is analogous to the way different puzzle pieces fit together to create a meaningful unit or how different nodes and linkages form a coherent network. The content is unique, but it integrates to form a meaningful pattern. Such constructs are functionally, but not structurally, equivalent across levels (Morgeson and Hofmann, 1999; Kozlowski and Klein, 2000). As an example, another type of team knowledge—transactive memory—is theorized to emerge in teams as a networked memory system. By knowing who knows

DOI: 10.1002/mde



Note: T1, T2, and T3 indicate sequential time periods. Horizontal arrows signify within unit variance. It exhibits maximum restriction in (a), maximum variation in (b), and exhibits no change in (c).

Figure 2. Emergence configurations.

what, team members can access the distinct expertise and knowledge of other members, thereby enabling collective access to knowledge as needed (Mohammed and Dumville, 2001). Transactive, networked memory emerges as a compilation construct because the knowledge is different across individuals, but the pattern is meaningful at the team level.

It is important to note that in both of these examples, emergence is assumed theoretically but is not directly observed. Knowledge (the elemental content) at the individual level (the point of origin) is the phenomenon of interest. Through different interaction process dynamics, it may emerge as a shared property of the team (e.g., team mental model, composition) or it may remain distinctive as team members develop the network structure that links disparate knowledge together (e.g., transactive memory, compilation). With respect to research on both these phenomena, the emergent processes are assumed theoretically but are not directly observed (Kozlowski and Bell, 2012). What differs are the ways that team mental models or transactive memory are represented.

Representing Emergent Constructs

We begin this section by highlighting the assumptions that bear on the construct validity of emergent constructs. We return to these issues as they are relevant to the ways that composition and compilation forms of emergent constructs are represented in organizational behavior research. Although both forms of emergence are likely to be relevant to organizational phenomena, by a wide margin the research has focused on composition forms of emergence.

Composition measures. Composition constructs are based on convergent processes that yield isomorphic, parallel constructs across levels; the same elemental content represented at two (or more) adjacent levels of a system. Such constructs are typically represented by aggregating individual level responses to a unit mean. However, if there is no verification of the theorized composition process, the mean is merely a descriptive property that lacks substantive meaning as a higher level construct. The unit mean is just descriptive of the average individual responding within the unit.

DOI: 10.1002/mde

Inference regarding relations between that descriptive mean and other unit level substantive constructs is difficult. Thus, for the mean to be meaningful as a unit construct, composition as an underlying theoretical process has to be verified.

The composition emergence process conceptualizes that individuals are bound proximally within a unit, shaped by forces that promote convergence in their cognitions, perceptions, and/or affective reactions, and therefore—as these assessments become shared over time—should exhibit evidence of restricted within-unit variance on the emergent constructs of interest. If there is no convergence, then one would expect individual differences to yield responses that are roughly normally distributed, with a reasonable amount of individual variability within the unit. Such a pattern of variability indicates that there is no composition emergence; the responses reflect individual properties. If there is convergence, then responses should cluster around the mean interpretation (James, 1982). Different statistical methods can be used to assess the restricted within-unit variance assumption, which is a basis for establishing the construct validity of the aggregated measure.[3] If within-unit variance is restricted, consistent with composition assumptions, the average is treated as a meaningful higher level construct. The important points are that (a) the result of an assumed composition process is assessed to provide evidence for construct validity and (b) composition emergence is not directly assessed. *The process of emergence is assumed and the representation is static.*

Compilation. Compilation constructs are based on divergent processes that yield functionally equivalent, but structurally different constructs across levels; different content that represents the same functional phenomenon at two (or more) levels of a model. Consider, for example, team performance. Members of a baseball team generate very different performance metrics at the player level that are commensurate with their role (e.g., pitcher, fielder, catcher), which do not map in a simple way to team performance. Rather, the team score is the result of a complex interaction among the individual performances, in dynamic competitive interaction with the other team, that yields team performance as a compilation construct.

Compilation constructs can manifest in a variety of different ways (Kozlowski and Klein, 2000). For example, team task structures can drive the configural nature of team performance. For conjunctive task structures (Steiner, 1972), such as a mountain climbing team (Krakauer, 1997), the weakest team member determines the upper limit of team performance, whereas for disjunctive task structures (Steiner, 1972), the strongest member determines team performance (e.g., a quiz team). Kozlowski and Klein (2000) classify these examples as a minimum/maximum type of compilation emergence. Other types include variance-based emergence based on unit member heterogeneity (e.g., demographic diversity; Tsui *et al*., 1992) and patterned emergence based on unit bifurcation (e.g., group faultlines; Lau and Murhighan, 1998), proportional thresholds (e.g., percent of female unit members; Hackman, 2003), or network metrics (e.g., density; Brass, 2012). Compilation forms of emergence have received much less attention in the research literature compared with the composition form.

Conclusion

Dynamic processes of convergence or divergence are inherent in both the composition and compilation forms of emergence. However, the press to assess constructs rather than to capture emergence processes *per se* as phenomena of interest has yielded a limited treatment in the literature. In the dominant approach, representation *assumes* that the dynamics of emergence have already unfolded and considers instead what the resulting emergent form should look like. Emergence is treated in a static fashion. Moreover, emergence is treated in a limited way, most often as a composition construct. Compilation forms of emergence, as dynamic processes, have been little explored. However, there is every reason to believe that forces for differentiation are prevalent and potent in organizations (Kozlowski and Klein, 2000). The sort of emergence represented by the boids illustration is not being addressed in MLT-based organizational behavior research and, thus, our ability to advance knowledge about the nature of emergence for psychological and social phenomena in organizations—what it is, how it varies, what shapes it—is hampered (Kozlowski, 2012a). We want to push research on emergence into quadrant 4 of Figure 1. We want to complement the precision of agent-based boids with the complexity of human actors—human 'noids'. We advance this goal next.

ADVANCING THEORY AND RESEARCH ON EMERGENCE

Teams: The Crucible of Emergence

As noted previously, we focus on teams in organizations because, at the meso level, teams are at the juncture of the micro origins of emergence, whereby individual

DOI: 10.1002/mde

level phenomena interact, intersect, and manifest over time as collective team properties, while being influenced by the higher level macro context (Hackman, 2003). Teams are the crucible of emergent phenomena in organizations (Kozlowski, 2012a). Our conceptualization is consistent with a contemporary perspective (Kozlowski *et al*., 1999; Arrow *et al*., 2000) that views 'the team as embedded in a *multilevel system* that has individual, team, and organizational level aspects; which focuses centrally on *task-relevant processes*; which incorporates *temporal dynamics* encompassing episodic tasks and developmental progression; and which views team processes and effectiveness as *emergent phenomena* unfolding in a proximal task- or social context that teams in part enact while also being embedded in a larger organization system or environmental context' (Kozlowski and Ilgen, 2006, p. 80).

The context or environment that surrounds a team generates episodic task demands. Team processes are conceptualized as the means by which team members combine their individual resources—cognitive, affective, motivational, and behavioral—to resolve task demands, thereby yielding some level of team performance. An unfolding, shifting, and changing environment creates fluctuations in task demands; team members endeavor to align *team processes* in ways that resolve them. This alignment is cyclical and reciprocal, such that team processes and team performance are emergent. When team processes are appropriately aligned with task demands, the team is effective; when they are not, it is not. Although there are a variety of team process constructs, or 'emergent states' (Marks *et al*., 2001), we focus our discussion on two core emergent processes that are important to team effectiveness: team cognition and team cohesion (Kozlowski and Ilgen, 2006).

Team Cognition

Over the last two decades, the concept of team cognition has developed from a seminal idea (Cannon-Bowers *et al*., 1993) to promising streams of research (Ilgen *et al*., 2005; Kozlowski and Ilgen, 2006) and to meta-analytic findings that demonstrate its contributions to team effectiveness (DeChurch and Mesmer-Magnus, 2010). Cognition, as a psychological concept, encompasses *learning processes* and *knowledge outcomes*; that breadth is represented in the conceptualization of team cognition as well. Often, the process and outcome distinction is not clear. As a consequence, scholars have been critical of the need to distinguish learning processes from resulting knowledge outcomes (Edmondson, 1999; Kozlowski *et al*., 1999; Kozlowski and Bell, 2008). This distinction is particularly important if we are to be able to examine how knowledge emerges from learning in teams (Bell *et al*., 2012).

In the remainder of this section, we concisely consider team learning and knowledge development as emergent phenomena.[4] First, we explicate team learning as a dynamic, multilevel, regulation-based composition process (DeShon *et al*., 2004) and then address a more recent conceptualization of team learning as a dynamic macrocognitive process (Fiore *et al*., 2010) that incorporates both compilation and composition forms of emergence. Second, we then discuss team knowledge outcomes in terms of team mental models (composition), transactive memory (compilation), and macrocognitive knowledge (emergence that evolves from compilation to composition). We highlight throughout how these approaches can advance a more dynamic and direct examination of the emergence of learning and knowledge in teams.

Team Learning Processes

Action regulation. Self-regulation models are the dominant explanation for learning, motivation, and performance in psychology (Kanfer *et al*., 2008). The key constructs of regulatory models include an action sequence of goals, goal commitment, strategies, effort, performance, feedback, comparison, and reactions; the process is cyclical and iterative (Bell *et al*., 2012).[5] Regulation is oriented by a goal, self-set or imposed, that is difficult and specific (Locke and Latham, 1990). A committed goal is directed by a task-dependent strategy and energized by cognitive/behavioral effort aimed at accomplishing the desired end-state. Difficult goals will typically yield performance information (feedback) that is lower than the target end-state. A comparison between the goal and current performance will yield a negative discrepancy and affective reactions to this gap. If the discrepancy is not too large in magnitude and the rate of goal closure is satisfactory, effort and strategy are adapted to maintain goal pursuit. If reactions are negative, the person will ruminate, reduce commitment, and withdraw resources, making goal accomplishment less likely (Kanfer, 1990). One can liken this heuristic sketch of self-regulation to the 'rules' that guide boid behavior in the earlier illustration.

Models of self-regulation have tended to focus on single goals. However, teams typically have a discretionary workflow structure (Steiner, 1972) that necessitates dual goals, one's own goals based on one's role, and collective goals to assist teammates when needed.

DOI: 10.1002/mde

In this task structure, individual goals and team goals are interdependent and cannot be pursued simultaneously. Individuals have to regulate the two goal-feedback loops, dynamically switching from individual goals to team goals as needed. Putting the dynamics of this multiple goal model in action, one can envision individuals comprising a team working toward individual goals but also having to monitor team goals and to dynamically switch regulatory resources when teammates need help. The result of such a process unfolding over time would be a multilevel homology—the composition of parallel team level regulatory constructs that emerge from the individual dynamics of dual goal pursuit and functional linkages at the team level that parallel those at the individual level. Research by DeShon *et al.* (2004) demonstrated that a homologous (i.e., parallel) multilevel regulation process emerged from the dynamic interactions of team members as they pursued individual and team goals. Subsequent research demonstrated how team regulation processes, having emerged from individual interactions, served as a higher level context that shaped team members' self-regulation (Chen *et al.*, 2009). This is a cross-level effect in which the higher level exerts influence on the lower level. Thus, the process of emergence creates structure that shapes process.

It is important to note that the emphasis in the DeShon *et al.* (2004) research is on a composition form of emergence. The regulatory constructs were parallel across levels and linked in a functionally equivalent fashion. Although the regulation process was dynamic and the data were longitudinal, the analytical focus was on establishing homology; the actual dynamics of emergence were not directly examined. However, this approach can focus on dynamics. For example, one could instead focus on directly assessing perceptual convergence that undergirds composition emergence (e.g., Figure 2(a)) and/or on the reciprocal exchanges among team members as they shifted to regulate team goals and performance. Thus, research on dynamic action regulation in teams has promise to more directly advance our understanding of the emergence of learning processes, motivational striving, and performance in teams.

Macrocognition. As described by Bell *et al.* (2012), the concept of macrocognition was developed in human factors and cognitive engineering as an approach for understanding naturalistic decision making in situations that entail high uncertainty, ill structured goals, and time pressure (Cacciabue and Hollnagel, 1995; Klein *et al.*, 2003). That it would be collaborative and emergent in teams was noted, but the idea was not developed. More recently, scholars have advanced a model of macrocognition for team collaboration (Fiore *et al.*, 2010) that is explicitly multilevel, dynamic, and emergent.

An important aspect of the model for the present discussion is that the process of collaborative cognition focuses on how unique knowledge is learned by team members (i.e., composition emergence), shared and exchanged through collaboration, and thereby emerges as a shared team property (i.e., composition emergence). The more knowledge that team members share in common, the better able they are to apply it to solving the problem or making the decision. The learning process begins with *individual knowledge building* as team members acquire information about the problem domain relevant to their unique expertise, yielding *internalized knowledge*. Internalized knowledge across team members represents a compilation form of emergence. Collaboration entails *team knowledge building*, as individual team members share information, exchange ideas, and construct an understanding that represents *externalized knowledge*. The process of collaboration yields a process in which the form of emergence transitions from compilation (i.e., distributed knowledge) to composition (i.e., shared knowledge). Shared, externalized knowledge is situated in the problem domain, integrates individual knowledge and expertise, and is the result of collaborative interactions and exchanges that drive the nature of emergence.

Team Knowledge Outcomes

The development of team knowledge outcomes has been conceptualized as different emergent forms. Team mental models are based on composition emergence, transactive memory is based on compilation emergence, and macrocognitive knowledge encompasses both forms. Research on team mental models and transactive memory has largely been consistent with quadrant 3 of Figure 1—emergence is assumed, not captured directly, and treated as static. Our research on knowledge emergence is consistent with quadrant 4—emergence is the research focus, measured directly, and examined dynamically.

Shared mental models and transactive memory. As we highlighted previously, shared mental models are conceptualized as team-level mental representations that are thought to guide team member interactions, enhancing coordination and team performance. They are composition-based team knowledge constructs thought to develop through convergent emergence processes. Team transactive memory, in contrast, is

DOI: 10.1002/mde

conceptualized as a team level, networked memory system. Individual experts on the team act as memory nodes, holding unique information, and team members can access that information by understanding who knows what. It is a compilation-based team knowledge construct that is thought to develop via divergent emergence processes. We will briefly discuss each conceptualization subsequently. It is important to highlight that even though emergence is at the heart of their conceptualizations, it is largely assumed, treated as static, and not directly examined.

Shared mental models are based on the idea that team members develop common mental representations around the team task, equipment used, member characteristics, and nature of team interaction processes (Cannon-Bowers *et al*., 1993). Originally developed in the human factors and cognitive engineering literatures, the idea of a mental model was of a 'working' mental representation of a technology system. A mental model was hypothesized to enable an expert to run mental scenarios of system functioning to diagnose problems or to anticipate future system states based on inputs. A good example of this concept is the radio program 'Car Talk', hosted by the 'Tappet Brothers' Tom and Ray, on National Public Radio.[6] Tom and Ray take questions about auto problems on this call-in show. Callers present car symptoms, the hosts ask questions, and then there is a diagnostic dialog as they run possible troubleshooting and fix-it scenarios (presumably) guided by their mental models of the systems in question. Extended to teams, shared mental models are hypothesized to enable team members to 'implicitly coordinate' without explicit communication because their actions are guided by shared understandings (Cannon-Bowers *et al*., 1993). Team mental models are composition constructs. There are a variety of measurement approaches used to assess team mental models, with no real consensus on the most appropriate method (Mohammed *et al*., 2010). For our discussion, the most important issue is that research generally focuses on the role of team mental models as a mediator between antecedents and team effectiveness. The emergence of team mental models has been neglected, although one could apply virtually any of the measurement approaches to capture the emergence of team mental models (e.g., McComb, 2008; McComb and Kennedy, 2012) or creation of meaning (Rentsch *et al*., 2008) over time. For example, one could assess the degree of mental model convergence at multiple time points. This would capture trajectories of convergence that reflect team mental model emergence (Kozlowski, 2012a). One could then apply growth modeling techniques to account for differences in the trajectories.

Transactive memory was originally researched in the context of how individuals in tight, intimate relationships formed distributed memory systems that allocated responsibility for certain classes of memory to one or another dyad member, but collectively comprised a common memory that both members could access (Wegner *et al*., 1985; Kozlowski and Bell, 2003). Transactive memory has often been described as analogous to a network structure such that individuals, as nodes, hold valuable and unique knowledge and network linkages represent how knowledge is connected or routed. By knowing who knows what, team members can access needed information held by other members. Rather than focusing on similarity, as in shared mental models, transactive memory, at least conceptually, is more focused on the distribution of knowledge across the team. In that sense, it is a configural or patterned conceptualization that is consistent with compilation forms of emergence. How transactive memory actually emerges in teams—direct assessments of its dynamics—has not been a research focus. For example, one could model the emergence of transactive memory using dynamical network analysis (Breiger *et al*., 2003). Information flow examined over time could show the emergence of expertise patterns that reflect transactive memory.

Capturing macrocognitive knowledge emergence. Assessing the emergence of macrocognitive knowledge necessitates measures that can span composition and compilation emergence. The macrocognition knowledge typology (Kozlowski and Chao, 2012) is theoretically grounded in the Fiore *et al*. (2010) model. In collaborative teams, individual experts have to acquire *unique* problem knowledge relevant to their expertise (individual knowledge building yields internalized knowledge), exchange and share internalized knowledge to build *collective* knowledge (team knowledge building yields externalized team knowledge), and then develop consensus on the best course of action to resolve the problem (Fiore *et al*., 2010).

The macrocognition knowledge typology is explicitly multilevel, dynamic, and emergent. First, it conceptualizes how knowledge representation in collaborative teams progresses from individually held internalized knowledge to collective team knowledge. Second, it is concerned with the transformation of unique knowledge to partially shared knowledge to common knowledge as team members construct an understanding of the problem. Third, the typology incorporates knowledge representations that encompass both compilation-based

DOI: 10.1002/mde

configural forms of emergence and composition-based shared forms of emergence. It captures how team knowledge evolves from a distributed compilation form of emergence to a shared composition form of emergence so the team knowledge is externalized, situated, and applicable.

The typology is a conceptual framework; metrics to operationalize it are domain specific. A fundamental assumption is that there is a total pool of relevant knowledge, unique and common, that is diagnostic for the problem or decision in question. Knowledge emergence is captured by tracking (a) *pools* of individual and common team knowledge; (b) *configurations* that index patterns of individual, partially shared, and fully shared knowledge; and (c) *variance* in the rates by which knowledge is acquired and emerges within and between teams over time.

Eight metrics are represented in the typology (Kozlowski and Chao, 2012).[7] *Individual knowledge* represents the proportion of the relevant pool that each individual team member has internalized; it is an individual level metric. *Knowledge pool* represents the proportion of the relevant pool that the team holds collectively, accounting for knowledge redundancies; it is a team level metric. *Knowledge configuration* differentiates individual knowledge, the knowledge pool, partially shared (dyadic), and fully shared (collective) knowledge; this metric cuts across the individual, dyadic, and team levels. It decomposes the pattern of knowledge distribution and current state of emergence as it evolves from compilation-based knowledge distribution patterns to composition-based shared, collective knowledge. Each of the preceding knowledge types is a static snapshot of the team at a particular point in its macrocognitive process.

A series of snapshots—a movie—is used to capture knowledge emergence. The next set of types captures the nature of that emergence. *Knowledge acquisition* captures the rate by which each team member acquires relevant knowledge. It is an indicator of *individual knowledge* growth. *Knowledge variability* captures within team variance in the rates of *knowledge acquisition*. It not only indexes differences in the rates of learning across team members, it also reflects the quality of collective learning processes. Ideally, fast rates of learning with restricted variance reflect better macrocognitive processes (Kozlowski and Chao, 2012). If the problem solving task structure requires all team members to share relevant knowledge, the slowest team member will impede team effectiveness—Steiner's (1972) conjunctive task structure. *Knowledge emergence* (within) tracks within team rates of growth for the *knowledge pool* and *knowledge configuration*, allowing a direct assessment of the pattern of knowledge emergence for each team. *Knowledge emergence* (between) tracks between team growth rates for *knowledge variability*, *knowledge pool*, and *knowledge configuration*, allowing direct comparison of the variance and patterns of knowledge emergence across teams.

The macrocognitive knowledge typology is a conceptual framework. It is designed to be applicable to a range of collaborative team problem situations, but the operationalization of the metrics for the knowledge types has to be task specific. Research has validated the typology using an agent-based simulation (Kozlowski *et al*., 2011). Like the boids, team members in the simulation are agents (droids) whose code conforms to a set of process 'rules' that are grounded in the model of macrocognition (Fiore *et al*., 2010) and the literature on collaborative decision making (e.g., Stasser and Titus, 1985). The typology metrics allow us to track the emergence of team knowledge across simulated collaborative events. The next step of our research will use the typology to track team knowledge emergence for human-based teams (noids) working collaboratively to solve a series of problems using a computer-based simulation. Eventually we plan to tune the agent simulation to model human macrocognition and to examine agent-based interventions that can move collaborative human problem solving closer to optimal performance. Our ability to measure knowledge emergence and to model its configuration and evolution over time will be critical to achieving that research goal.

Team Cohesion

A static perspective. Among the many team processes that have been investigated, there is no other emergent state that has been as heavily researched as team cohesion. First proposed by Festinger (1950), it was defined as 'the resultant of all the forces acting on the members to remain in the group' (p. 274) and was composed of three facets: mutual social attraction, commitment to the team task, and group pride. Subsequent research has primarily focused on social and task cohesion facets. Cohesion has been studied for over 60 years and there are no fewer than eight (and counting) published meta-analyses that substantiate the relationship between team cohesion and team effectiveness (e.g., Beal *et al*., 2003). The vast majority of this research is based on cross-sectional data. Thus, our understanding of the team cohesion-performance relationship is static.

DOI: 10.1002/mde

Although we know that team cohesion is related to team effectiveness, other than experience, there is little direct empirical research on factors that shape the formation and emergence of team cohesion (Kozlowski and Ilgen, 2006). Theories of team development suggest that cohesion forms relatively quickly and that it enables members to focus on developing other capabilities (i.e., collective efficacy, coordination, and adaptation; Kozlowski *et al*., 1999). Although there are suggestive data to support this supposition, direct evidence is lacking. How team cohesion (and other team processes) emerges, the forms it may assume, and its stability/variability over time are relative unknowns.

Antecedents of cohesion emergence. Theoretical explanations for the emergence of team cohesion can be found in social identity theory and social exchange theory. Social identities emerge as a natural process of self-definition; they are self-categories based on shared similarities with a specific group of people (Turner *et al*., 1994). Individuals are motivated to bond to groups to satisfy a need to belong (Baumeister and Leary, 1995). Identification with a team that is positively valued can enhance an individual's self-definition and self-esteem (Hogg and Terry, 2001). By identifying with a group or team, individuals share resources, labor, and knowledge that produce outcomes that could not be obtained alone. Furthermore, cohesive teams provide social support and protect a member from rival teams. For new teams, a social identity with that team emerges from a series of social exchanges among team members.

The development of social exchanges within a team establishes group norms that influence the emergence of team cohesion. The nature of these exchanges is dynamic with early exchanges shaping the nature of later ones (Allport, 1954). Rewarding exchanges lead to positive relationships that build team cohesion, whereas punishing exchanges discourage future interactions (Homans, 1974). Thus, the impact of early exchanges can be critical to the success or failure of a team. However, early social exchanges among members of a new team are based on limited information if members were strangers to one another before the team was formed. Initial interactions may be based on stereotypes or expectations an individual team member may have for the team or for his or her role on the team.

Developing and maintaining positive interpersonal relations among team members can be a formidable challenge. Team members need to communicate well, coordinate their activities, anticipate and meet the needs of other team members, and adapt behavior to improve team performance (Cannon-Bowers *et al*., 1993). These interactive behaviors are more likely when individuals have a deep understanding of other team members' values, attitudes, and behavioral tendencies. A quick way to make sense of, or understand another individual, is to identify the important groups, or social identities, to which that person belongs. Chao and Moon (2005) developed the *cultural mosaic* to extend the concept of 'culture' beyond definitions of national culture in order to capture how shared values emerge from common experiences of people. Besides nationality, many factors define a group of people.

The Chao and Moon (2005) cultural mosaic metatheory redefines the usual nation-level interpretation of culture to include associative, demographic, and geographic group factors. When culture is defined by shared values and behaviors among a specific group of people, multiple cultural identities emerge. Associative cultural identities draw on different social identities such as professions, religions, or organizations. Demographic cultural identities are based on characteristics such as gender, race, or age. Finally, geographic cultural identities are shaped by natural or man-made environments such as rural/urban, coastal/in-land, or temperate/tropical distinctions. Multiple cultural identities form a cultural mosaic within individuals, offering a variety of values and behaviors that can facilitate or impede team-building.

Dynamics of cohesion emergence. First impressions set the tone for early interactions, and these interactions then serve as feedback for individuals to adapt and the relationship continually evolves. Initial interactions are influenced by surface-level group identities and later progress to deep-level forms of culture (cf. Harrison *et al*., 2002). Surface-level characteristics are immediate, obvious features (e.g., race, gender, and age) and constitute demographic identities. When homogeneous (composition), they can provide the core for a common identity to emerge. When heterogeneous (compilation), these features can separate groups along demographic identities or faultlines that define identity clusters (Lau and Murhighan, 1998). The salience of these group identities and their influence on interpersonal behaviors are likely to operate at conscious and non-conscious levels. They influence expectations and behaviors that set initial conditions for team building.

Subsequent interactions can rise above superficial differences, moving team members away from surface-level differences to focus on deep-level forms of diversity. These forms include individual differences such as personality traits, knowledge, and expertise, and they may also be value-based and influenced by cultural or social identities. Time is viewed as a critical component

DOI: 10.1002/mde

where different group identities are salient at different developmental stages of team building and relationship maintenance. Cultural code-switching (Molinsky, 2007) describes how individuals can use different cultural identities to relate to another person. If one cultural or social identity fails to strike a common chord in another person, perhaps a different group identity can establish a bond. Given a wide variety of demographic, geographic, and associative group identities within each individual, the probability that two individuals have one or more groups in common is high. Positive interpersonal relationships are more likely to happen when common group identities link individuals together.

When common group identities are made salient to prospective team members, the seeds for team cohesion are sown and other team 'emergent states' (Marks *et al.*, 2001) can develop. Members with similar values and attitudes toward the team are more likely to develop common mental representations of the team's tasks, member contributions to the team, and what the team means to its members (i.e., social identity). This knowledge can facilitate communication and expedite team cohesion. This form of team cohesion, built upon the shared group identities of a cultural mosaic, is a composition form of emergence.

However, new teams may be more aware of the differences among members than the similarities. Diversity in organizational groups has been found to have multiple effects on group satisfaction and performance. Research on demographically diverse groups generally finds that dissimilar group members are more likely to be absent or leave the group. However, diverse groups that stay together beyond an initial period may benefit from an increased ability to generate decision alternatives and to cooperate with one another (Milliken and Martins, 1996). On a negative trajectory, diversity can yield groups that polarize along 'faultlines' on a cultural mosaic, cleaving the group along identity clusters into conflicting subgroups. Conversely, on a positive trajectory, diversity can offer complementary tiles on a cultural mosaic, creating a new, unique social identity that distinguishes the group as a whole. Like the different pieces in a jigsaw puzzle, diverse group identities can be compiled to create a picture or group that is not apparent from one piece or individual. This form of team cohesion, built upon different but complementary group identities of a cultural mosaic, is a compilation form of emergence.

Early interactions among team members establish a socialization process from which team cohesion emerges. The emergence of new links between team members is dynamic and nonlinear. Thus, changing salient group identities can help team members adjust to one another. Shared experiences related to teamwork create a new group identity for team members. Values associated with a new team can emerge and add to the cultural mosaic of each team member, providing additional information to draw upon when these individuals engage in future interpersonal relationships. Successfully drawing upon similarities to build team cohesion represents a composition form of emergence, whereas successfully drawing upon differences to build team cohesion represents a compilation form of emergence.

Researching cohesion emergence. How can we study the dynamics of the cohesion emergence process? As noted previously, cohesion has tended to be examined with cross-sectional data. Clearly, examining its emergence necessitates longitudinal research designs. What would such data reveal? For example, one might expect that composition forms of cohesion emergence would demonstrate a pattern such that newly formed teams exhibit a normal distribution of cohesion perceptions, signifying many different individual viewpoints, that becomes increasingly convergent over time as members interact, forge an identity, and bond to the team (e.g., Figure 2(a)), but perhaps the process of emergence is not so neat.

Cohesion emergence might be more complex. For example, longitudinal studies using experience sampling methods of state (i.e., momentary) that affect fluctuations at the individual level show that affect varies and cycles around baselines (Kuppens *et al.*, 2010). Individuals have 'characteristic' baseline levels of affect with *intra*-individual variability, but there is also considerable *inter*-individual variability in the extent to which affect fluctuates; some people are more and others less emotionally even. Because team cohesion is largely an affectively laden attraction to the team and its task, one might expect team cohesion to exhibit fluctuations and cycles of variation. How individual affect variation and cycles intersect could influence the nature of team cohesion dynamically. For example, team cohesion data were collected weekly from new work teams that formed up and provided weekly assessments of team cohesion. Examination of patterns of within team variance on cohesion indicated considerable variability in the nature of its emergence across the 8 weeks of observation. Some teams evidenced convergence over time, as would be expected for composition processes (Figure 2(a)). Other teams exhibited unstable patterns of convergence and divergence, such that cohesion converged (Figure 2(a)) and

DOI: 10.1002/mde

then diverged (Figure 2(b)); emergence was quite variable (Kozlowski *et al*., 2010).

Moreover, because cohesion is affectively loaded, one might expect that interpersonal conflicts (or faultlines) would fracture cohesion. This would have implications for cohesion as an emergent state. It could vary from a composition (convergent) construct (Figure 2(a)) to one that is compilation in form (divergent; Figure 2(b)), and then through restoration it could again converge (Figure 2(a)). For example, data collected using experiencing sampling methods (i.e., daily diaries) for two teams over a 6-week period exhibited two distinct patterns. Team A evidenced a relatively uniform high level of cohesion across the 6 weeks, whereas team B evidenced a saw-tooth pattern of cohesion across the observations. Analyses indicated that conflicts around a focal team member related to the saw-tooth pattern (Pearce *et al*., 2011). Thus, an individual can shape the form of team cohesion emergence and its dynamics. A variety of contingencies—contextual, interpersonal, individual—could influence its emergence, its form, and its variance. Emergence is equifinal.

DISCUSSION

The purpose of this article was to highlight current treatments of emergence in the micro–meso organizational behavior literature, identify key limitations in the extant research, and illustrate how an explicit consideration of *emergence as a dynamic process* can advance theory development and research. We began by illustrating that much of the treatment of emergence in organizational science has been indirect. Emergence is typically treated as an *assumed* process captured qualitatively via retrospective sensemaking (Figure 1, quadrant 1) or quantitatively by retrospective, cross-sectional surveys (Figure 1, quadrant 3). Although there are efforts to capture emergence more directly, they have generally been limited to qualitative, participant observation cases that situate the observer/interpreter in the midst of the process (quadrant 2) or quantitative efforts to model emergence via agent-based computational models (quadrant 4). The approaches represented in quadrants 2 and 4 have clear value but are also limited. Quadrant 2 approaches provide rich descriptions of context and process but cannot unpack the elemental interactions that undergird emergence. Quadrant 4 approaches can unpack the complexities of elemental interactions, but these are synthetic worlds based on an array of assumptions and parameter estimates. We believe that our understanding of emergence can be advanced by better integrating the strengths of the different approaches and, *in particular*, by pushing research on micro–meso emergence—which has been stuck in quadrant 3—into quadrant 4. We believe emergence in organizational behavior should be investigated directly, quantitatively, and with human actors to supplement computational methods.

In the micro–meso literature of organizational behavior, current treatments of emergence are principally concerned with establishing the construct validity of aggregated lower level measures that are used to represent emerged phenomena (Kozlowski and Klein, 2000). Although this concern provides important inferential strengths (Chan, 1998), it also entails substantial conceptual costs. First, even though it is axiomatic that the emergence of lower level characteristics as higher level phenomena are dynamic processes, current practices treat emergence as static representations. Second, emergence is not assessed directly; rather it is inferred by examining point estimates of within-unit variance (or sometimes other indicators). Thus, beyond theoretical explorations, the literature reveals little about the nature of the emergence of social psychological phenomena in organizations. Third, even though theoretical frameworks postulate a range of different emergent forms (Kozlowski and Klein, 2000), the vast majority of research has focused on convergent forms of emergence. Divergent forms of emergence have been relatively neglected and little explored. Our goal in this article was to push beyond the status quo and to explore more dynamic and multifaceted conceptualizations of emergence with illustrations from the research areas of team cognition and team cohesion.

We should, of course, acknowledge that there are other areas of social organizational theory and research that, although not focused on the processes of emergence directly, study phenomena that are emergent. Indeed, research on social dilemmas (e.g., Kollock, 1998), as well as other areas (e.g., negotiation; De Dreu, 2010), has a long tradition in organizational science. Implicitly, such research is interested in the emergence of conflict or cooperation between the individual and the collective, but the interest is not explicit. Although multilevel emergence—the nature of the process by which collective behavior arises—could be a focal interest, it has generally not been central in social dilemma research. For the most part, research designs tend to (a) examine single dilemmas (i.e., there is no emergence process to assess; e.g., Kiyonari and Barclay, 2008), (b) aggregate over actors and multiple dilemma choices (i.e., the interplay across levels is not addressed and process is collapsed into a static metric; e.g., Agarwal

DOI: 10.1002/mde

et al., 2010), or (c) model longitudinal linear change in a collective property (i.e., change in the level of the emerged property is examined but not the process of emergence *per se*; e.g., Axelrod, 2006). Such research could examine emergence as a process explicitly by modeling dilemma choice dynamics (i.e., examining reciprocal linkages of actor choices across dilemma instances) and/or by utilizing computational modeling and simulation (e.g., Gotts *et al*., 2003); recommendations that parallel those we suggest for team researchers.

Implications for Researching Emergence

One of the big reasons that micro–meso organizational behavior research is so focused on the construct validity of emerged measures is due to the field's heavy reliance on perception/reaction-based survey instruments. Survey questionnaires are the primary data gathering tool. The method limits what reactions researchers can reasonably gather and how frequently they can assess emergent phenomena. The use of surveys is a big contributor to the dominance of cross-sectional research in the micro–meso organizational behavior disciplines. Organization behavioral science needs to stop relying solely (or nearly so) on perception-based surveys! Economic and strategy researchers are fortunate because so much longitudinal data are generated routinely (e.g., economic statistics, firm performance). As discussed previously, such aggregates have inferential limits with respect to the underlying psychology and the mechanics of emergence. Nonetheless, they do allow modeling of consequential descriptive phenomena over time. Organizational behavior researchers need to become more adroit at developing other methods of data collection. Well-developed, psychometrically sound surveys are not going to disappear, but they need to be supplemented by other data gathering methodologies that can provide behavioral data streams over time (Kozlowski, 2012b).

For example, as we highlighted previously, one line of research we are conducting is focused on the dynamic emergence of team knowledge—its transformation from individual to dyadic to team levels—in decision making teams (Kozlowski and Chao, 2009; Kozlowski *et al*., 2011). First, the research is based on an integration of MLT and the theory of macrocognition used to develop a measurement typology designed to capture the dynamic emergence of team knowledge from divergent, compilation patterns of individual and dyadic knowledge to collective, convergent, composition knowledge. Second, we used the theoretical mechanisms to develop a computational model of learning, knowledge acquisition, and sharing. An agent-based simulation (analogous to the boids) was used to validate the measurement typology and to assess the utility of the metrics to track different patterns of knowledge emergence in our synthetic teams (our droids). Third, we developed a human-based team simulation as an experimental platform to examine the emergence of team knowledge—and our ability to shape it with interventions—with human actors (human-noids). Data are collected using computers so that the dynamics and complexities of knowledge emergence can be tracked with precision. This is an effort to push the focus of MLT research from quadrant 3 to quadrant 4 so emergence can be assessed directly, its dynamics can be unpacked, and its different forms captured. Bringing the study of emergence into the lab is one way to examine its dynamic complexities.

To complement this approach, we are also interested in studying the dynamics of emergence in the 'wild'. In today's technologically dense society, people give off streams of behavioral data throughout their daily activities; much of it assessed without their explicit consent![8] Organizational behavior researchers need to become more sophisticated at tapping into analogous behavioral streams and extracting meaning. For example, we are conducting research on the emergence of team cohesion (Kozlowski *et al*., 2009). One of the cohesion measurement techniques we are developing is a wireless sensor that monitors a team member's dynamic collaboration and interaction with other team members (e.g., collaboration time, distance, frequency, initiation, and disengagement), vocalization, and physiological arousal. Long term, the intent is to be able to deploy the sensor in 'real' teams and to assess cohesion dynamically and in real time. The sensor has the potential to give off rich streams of behavioral data that can be used to track the emergence of team cohesion, shocks that fracture it, and fluctuations or cycles of cohesion emergence that may be entrained to contextual factors. Indeed, we have the potential to drown in data (the 'drinking from a fire hose' analogy comes to mind). The keys will be filtering the data to extract meaningful clusters of behavior and synchronizing or 'fusing' the behavioral data with psychosocial assessments of team cohesion (and other team processes). Then, sophisticated dynamical modeling techniques can be applied to extract patterns of cohesion emergence from the dynamic data (DeShon, 2012).

In addition to our research examples, there is a host of technologies deployed or under development that has the potential to provide new and sophisticated insights on micro–meso emergence. For example, some researchers capture communications in teams (via automated speech-to-text processing or via chat logs)

DOI: 10.1002/mde

and apply dynamical analyses to identify the emergence of compilation patterns indicative of particular phases of decision making or places where teams get stuck on the problem (Cooke *et al*., 2008). Other researchers have tracked information packets in technology-based team systems (i.e., where team members exchange task information electronically) to model the emergence of bottlenecks that impede workflow, inefficiencies that slow it down, and optimal paths in workflow networks (Lo *et al*., 2011). There are even efforts to model the neuropsychology of teamwork using wireless EEG monitors to track the emergence of synchronicity among team members working on a collaborative task (Stevens *et al*., 2009). We will admit that some of these examples are pretty far out there and require resources, but there is the potential to assess more ordinary behavior (e.g., email linkages, chat) or to use more mundane methods (e.g., experience sampling diaries) to capture the dynamics of emergence. We think that organizational behavior researchers should explore and pioneer new techniques to do so.

Closing the Gap: Micro, Meso, and Macro

Our article has focused on individual to team, micro to meso emergence in organizational behavior. The meso—in between level—is the most proximal context for individual interaction in organizations (Indik, 1968) and, thus, is the principal crucible for the emergence of psychosocial phenomena. It is also where our research interests lie and where our research is focused. However, this does not mean that emergence stops at the meso level. Things become more complex—indeed, far more complex—as one seeks to span more levels of the organizational system, but that is an important frontier for organizational science to cross. There are two key challenges to surmount to cross that frontier: (1) dealing with system complexity and (2) bridging disciplinary divides.

From MLT we know that consequential outcomes at any given level of the organizational system are multiply determined (Katz and Kahn, 1966), with the number of potential determinants expanding substantially as one moves to higher levels of the system (Kozlowski and Klein, 2000). Thus, as we seek to trace micro contributions to consequential macro outcomes such as firm performance, we have to be mindful of the multiplicity of influences—both contextual and emergent—across the intervening levels of the system that complicates such efforts. To describe this problem as 'complex' is an understatement! However, just because it will be difficult does not mean that it should not be pursued. For example, it is now well established by several meta-analytic investigations that firm-level high performance work practices (HPWPs) relate to firm performance (Kozlowski, 2011). HPWPs—such as scientific selection, training and development, and performance management—represent firm investments in the quality of its collective human resources. The big question is, what are the micro underpinnings by which such practices influence effects on firm performance? The principles of MLT make it clear that there have to be underlying contextual and emergent mechanisms driving such influences, but what are they and how do they work (Ostroff and Bowen, 2000; Ployhart, 2012)? Theory and research are beginning to probe this frontier (e.g., see Ployhart *et al*., 2009; Van Iddekinge *et al*., 2009 for notable empirical exemplars). In particular, an insightful theoretical paper by Ployhart and Moliterno (2011) developed a multilevel model of the emergence of human capital. An important aspect of their conceptualization is on unit-level 'enabling' processes that link micro–meso emergence (as discussed in this article) to higher levels in the system. Their insight is that emergence beyond the meso level is multiply determined. System interactions amplify and shape how human capital emergence influences firm performance.

Bridging conceptual levels of the organizational system is one challenge; bridging disciplinary barriers is another. Roberts *et al*. (1978) noted how different disciplines had sliced the organizational system into distinct levels with little cross-talk across distinct literatures. The advent of MLT principles, measurement prescriptions, and analytics has energized research that is starting to bridge levels of the system. However, disciplinary barriers with their entrenched perspectives/assumptions, language/jargon, and methods/analytics remain a significant block to progress—a 'disciplinary divide' (Molloy *et al*., 2011). This is the next big domino that needs to fall to push *emergence* to the forefront of research in organizational science. We hope that some of our examples and suggestions can help to make this happen.

Acknowledgements

We gratefully acknowledge the Office of Naval Research (ONR), Command Decision Making Program (N00014-09-1-0519, S.W.J. Kozlowski and G. T. Chao, Principal Investigators) and the National Aeronautics and Space Administration (NASA, NNX09AK47G, S. W.J. Kozlowski, Principal Investigator) for support that, in part, assisted the composition of this article. Any opinions, findings, and conclusions or recommendations expressed are those of the authors and do not necessarily reflect the views of ONR or NASA.

NOTES

1. The micro and meso disciplines include organizational psychology, organizational behavior, and human resource management and for simplicity hereafter referred to as organizational behavior.
2. For simplicity of presentation, we refer to micro (individual), meso (group, team), and macro (organizational) levels of phenomena. The dynamic interplay of processes within and across these levels is at the core of understanding emergence as a process and the manifestation of emergent phenomena.
3. Consensus-based approaches assess inter-rater agreement, whereas consistency-based approaches assess inter-rater reliability (Kozlowski and Hattrup, 1992; Bliese, 2000); these differences are not important to this discussion.
4. See Kozlowski and Bell (2008) and Bell *et al*. (2012) for more in-depth treatments.
5. There is an extensive literature on self-regulation with several specific models. Although differences among the models are of theoretical importance, they are not relevant for our purpose. Moreover, there are common components across the models and this heuristic is used to draw attention to those core constructs and process mechanisms.
6. http://www.cartalk.com/
7. This illustration assumes a 3-person team.
8. Apple and Google collect user location data (http://online.wsj.com/article/SB10001424052748703983704576277101723453610.html)

REFERENCES

Agarwal R, Croson R, Mahoney JT. 2010. The role of incentives and communication in strategic alliances: an experimental investigation. *Strategic Management Journal* **31**: 413–437.

Allport FH. 1954. The structuring of events: outline of a general theory with applications to psychology. *Psychological Review* **61**: 281–303.

Arrow H, McGrath JE, Berdahl, JL. 2000. *Small Groups as Complex Systems: Formation Coordination, Development, and Adaptation*. Sage: Thousand Oaks, CA.

Arthur WB. 1994. On the evolution of complexity. In *Complexity: Metaphors, Models, and Reality*, Cowan G, Pines D, Meltzer D (eds). Addison-Wesley: Reading, MA; 65–77.

Axelrod R 2006. *The Evolution of Cooperation*: Revised edition. Basic Books: New York.

Baumeister RF, Leary MR. 1995. The need to belong: desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin* **117**: 497–529.

Beal DJ, Cohen RR, Burke MJ, McLendon CL. 2003. Cohesion and performance in groups: a meta-analytic clarification of construct relations. *Journal of Applied Psychology* **88**: 989–1004.

Bell BS, Kozlowski SWJ, Blawath S. 2012. Team learning: a review and integration. In *The Oxford Handbook of Organizational Psychology*, Kozlowski SWJ (ed). Oxford University Press: New York; 859–909.

Bliese PD. 2000. Within-group agreement, non-independence, and reliability: implications for data aggregation and analysis. In *Multilevel Theory, Research, and Methods in Organizations: Foundations, Extensions, and New Directions*, Klein KJ, Kozlowski SWJ (eds). Jossey Bass: San Francisco; 349–381.

Boulding KE. 1956. General systems theory: the skeleton of science. *General Systems* **1**: 1–17.

Boyd BK, Gove S, Hitt MA. 2005. Construct measurement in strategic management research: illusion or reality? *Strategic Management Journal* **26**: 239–257.

Brass DJ. 2012. A social network perspective on organizational psychology. In *The Oxford Handbook of Organizational Psychology*, Kozlowski SWJ (ed). Oxford University Press: New York; 667–695.

Breiger R, Carley KM, Pattison P. 2003. Dynamic social network modeling and analysis: workshop summary and papers. Committee on Human Factors, Board on Behavioral, Cognitive, and Sensory Sciences. National Academies Press: Washington, DC.

Cacciabue PC, Hollnagel E. 1995. Simulation of cognition: applications. In *Expertise, and Technology: Cognition and Human-Computer Cooperation*, Hoc JM, Cacciabue PC, Hollnagel E. (eds). LEA: Hillsdale, NJ; 55–73.

Cannon-Bowers JA, Salas E, Converse S. 1993. Shared mental models in expert team decision making. In *Individual and Group Decision Making: Current Issues*, Castellan, Jr. NJ (ed). Lawrence Erlbaum: Hillsdale, NJ; 221–246.

Chan D. 1998. Functional relations among constructs in the same content domain at different levels of analysis: a typology of composition models. *Journal of Applied Psychology* **83**: 234–246.

Chao GT. 2012. Organizational socialization: background, basics, and a blueprint for adjustment at work. In *The Oxford Handbook of Organizational Psychology*, Kozlowski SWJ (ed). Oxford University Press: New York; 579–614.

Chao GT, Moon H. 2005. The cultural mosaic: a metatheory for understanding the complexity of culture. *Journal of Applied Psychology* **90**: 1128–1140.

Chen G, Kanfer R, DeShon RD, Mathieu JE, Kozlowski SWJ. 2009. The motivating potential of teams: test and extension of Chen and Kanfer's (2006) cross-level model of motivation in teams. *Organizational Behavior and Human Decision Processes* **110**: 45–55.

Cooke NJ, Gorman JC, Kiekel PA. 2008. Communication as team-level cognitive processing. In *Macrocognition in Teams: Theories and Methodologies*, Letsky MP, Warner NW, Fiore SM, Smith CAP (eds). Ashgate Publishing: Burlington, VT; 51–64.

Crutchfield JP. 1994. Is anything ever new? Considering emergence. In *Complexity: Metaphors, Models, and Reality*, Cowan G, Pines D, Meltzer D (eds). Addison-Wesley: Reading, MA; 515–533.

De Dreu CKW. 2010. Social conflict: the emergence and consequences of struggle and negotiation. In *Handbook of Social Psychology*, Fiske ST, Gilbert DT,Lindzey G. (eds). Wiley & Sons: Hoboken, NJ; 983–1023.

DeChurch LA, Mesmer-Magnus JR. 2010. The cognitive underpinnings of effective teamwork: a meta-analysis. *Journal of Applied Psychology* **95**: 32–53.

DeShon RP. 2012. Multivariate dynamics in organizational science. In *The Oxford Handbook of Organizational Psychology*, Kozlowski SWJ (ed). Oxford University Press: New York.

DOI: 10.1002/mde

DeShon RP, Kozlowski SWJ, Schmidt AM, Milner KR, Wiechmann D. 2004. A multiple goal, multilevel model of feedback effects on the regulation of individual and team performance. *Journal of Applied Psychology* **89**: 1035–1056.

Edmondson A. 1999. Psychological safety and learning behavior in work teams. *Administrative Science Quarterly* **44**: 350–383.

Festinger L. 1950. Informal social communication. *Psychological Review* **57**: 271–282.

Fiore SM, Rosen MA, Smith-Jentsch KA, Salas E, Letsky M, Warner N. 2010. Toward an understanding of macrocognition in teams: predicting processes in complex collaborative contexts. *Human Factors* **52**: 203–224.

Flake GW. 1998. *The Computational Beauty of Nature: Computer Explorations of Fractals, Chaos, Complex Systems, and Adaptation*. MIT Press: Cambridge, MA.

Gell-Mann M. 1994. Complex adaptive systems. In *Complexity: Metaphors, Models, and Reality*, Cowan G, Pines D, Meltzer D (eds). Addison-Wesley: Reading, MA; 17–29.

Gotts NM, Polhill JG, Law ANR. 2003. Agent-based simulation in the study of social dilemmas. *Artificial Intelligence Review* **19**: 3–92.

Hackman JR. 2003. Learning more by crossing levels: evidence from airplanes, hospitals, and orchestras. *Journal of Organizational Behavior* **24**: 905–922.

Harrison DA, Price KH, Gavin JH, Florey AT. 2002. Time, teams, and task performance: changing effects of surface- and deep-level diversity on group functioning. *Academy of Management Journal* **45**: 1029–1045.

Hogg MA, Terry DJ. 2001. Social identity theory and organizational processes. In *Social Identity Processes in Organizational Contexts*, Hogg MA, Terry DJ (eds). Psychology Press: Philadelphia, PA; 1–12.

Homans GC. 1974. *Social Behavior: Its Elementary Forms*. Harcourt, Brace, Jovanovich: New York.

Ilgen DR, Hollenbeck JR, Johnson M, Jundt D. 2005. Teams in organizations: from I-P-O models to IMOI models. *Annual Review of Psychology* **56**: 517–543.

Indik BP. 1968. The scope of the problem and some suggestions toward a solution. In *People, Groups, and Organizations*, Indik BP, Berren FK (eds). Teachers College Press: New York; 3–30.

James LR. 1982. Aggregation bias in estimates of perceptual agreement. *Journal of Applied Psychology* **67**: 2l9–229.

Kanfer R. 1990. Motivation and individual differences in learning: an integration of developmental, differential and cognitive perspectives. *Learning and Individual Differences* **2**: 221–239.

Kanfer R, Chen G, Pritchard R. 2008. Work motivation: forging new perspectives and directions in the post-millennium. In *Work Motivation: Past, Present, and Future*, Kanfer R, Chen G, Pritchard RD (eds). Routledge: New York; 601–632.

Katz D, Kahn RL. 1966. *The Social Psychology of Organizations*. Wiley: New York.

Kemmis S, McTaggart R. 2005. Participatory action research: communicative action and the public sphere. In *The Sage Handbook of Qualitative Research* (3rd edn), Denzin NK, Lincoln YS (eds). Sage: Thousand Oaks, CA; 559–603.

Kiyonari T, Barclay P. 2008. Cooperation in social dilemmas: free riding may be thwarted by second-order reward rather than by punishment. *Journal of Personality and Social Psychology* **95**: 826–842.

Klein G, Ross K, Moon BM, Klein DE, Hoffman RR, Hollnagel E. 2003. Macrocognition. *IEEE Intelligent Systems* **18**: 81–84.

Kollock P. 1998. Social dilemmas: the anatomy of cooperation. *Annual Review of Sociology* **24**: 183–214.

Kozlowski SWJ. 2011. Workforce effectiveness: acquiring human resources and developing human capital. In *Intelligence Analysis: Behavioral and Social Scientific Foundations*, Fischhoff B, Chauvin C (eds). National Academies Press: Washington, DC.

Kozlowski SWJ. 2012a. Groups and teams in organizations: studying the multilevel dynamics of emergence. In *Methods for Studying Small Groups: A Behind-The-Scenes Guide*, Hollingshead AB, Poole MS (eds). Routledge Academic: New York, NY; 260–283.

Kozlowski SWJ. 2012b. On the horizon. In *The Oxford Handbook of Organizational Psychology*, Kozlowski SWJ (ed). Oxford University Press: New York; 1385–1389.

Kozlowski SWJ, Bell BS. 2003. Work groups and teams in organizations. In *Handbook of Psychology: Industrial and Organizational Psychology*, Borman WC, Ilgen DR, Klimoski RJ (eds). Wiley: London; 333–375.

Kozlowski SWJ, Bell BS. 2008. Team learning, development, and adaptation. In *Group Learning*, Sessa VI, London M. (eds). LEA: Mahwah, NJ; 15–44.

Kozlowski SWJ, Bell BS. 2012. Work groups and teams in organizations: review update. In *Handbook of Psychology: Industrial and Organizational Psychology* (2nd edn), Schmitt N, Highhouse S. (eds). Wiley: London; 412–469.

Kozlowski SWJ, Chao GT. 2009. Team knowledge: origins, emergence, and measurement. Office of Naval Research (N00014-09-1-0519).

Kozlowski SWJ, Chao GT. 2012. Macrocognition, team learning, and team knowledge: origins, emergence, and measurement. In *Theories of team cognition: Cross-disciplinary perspectives*, Salas E, Fiore S, Letsky M. (eds). Routledge Academic: New York; 19–48.

Kozlowski SWJ, Doherty ML. 1989. An integration of climate and leadership: examination of a neglected issue. *Journal of Applied Psychology* **74**: 546–553.

Kozlowski SWJ, Hattrup K. 1992. A disagreement about within-group agreement: disentangling issues of consistency versus consensus. *Journal of Applied Psychology* **77**: 161–167.

Kozlowski SWJ, Ilgen DR. 2006. Enhancing the effectiveness of work groups and teams (monograph). *Psychological Science in the Public Interest* **7**: 77–124.

Kozlowski SWJ, Klein KJ. 2000. A multilevel approach to theory and research in organizations: contextual, temporal, and emergent processes. In *Multilevel Theory, Research and Methods in Organizations: Foundations, Extensions, and New Directions*, Klein KJ, Kozlowski SWJ (eds). Jossey-Bass: San Francisco, CA; 3–90.

Kozlowski SWJ, Chao GT, Grand J, Keeney J, Braun M, Kuljanin G. 2011, April. Macrocognition and teams: the emergence and measurement of team knowledge In *Macrocognition: The next frontier for team cognition research.* Chao GT, Kozlowski SWJ (chairs). Symposium presented

at the 26th Annual Conference of the Society for Industrial and Organizational Psychology, Chicago, IL.
Kozlowski SWJ, DeShon RP, Schmitt N, Biswas S. 2009. Developing, maintaining, and restoring team cohesion. National Aeronautics and Space Administration (NNX09AK47G).
Kozlowski SWJ, Gully SM, Nason ER, Smith EM. 1999. Developing adaptive teams: a theory of compilation and performance across levels and time. In *The Changing Nature of Work Performance: Implications for Staffing, Personnel Actions, and Development*, Ilgen DR, Pulakos ED. (eds). Jossey-Bass: San Francisco; 240–292.
Kozlowski SWJ, Ployhart RP, Lim BC. 2010, April. The developmental role of team leaders. In *Current perspectives on leadership in collective work arrangements*, Resick C, Doty D (chairs). Symposium presented at the 25th Annual Conference of the Society for Industrial and Organizational Psychology, Atlanta, GA.
Krakauer J. 1997. *Into Thin Air*. Villard: New York.
Kuppens P, Oravecz Z, Tuerlinckx F. 2010. Feelings change: accounting for individual differences in the temporal dynamics of affect. *Journal of Personality and Social Psychology* **99**: 1042–1060.
Lau DC, Murhighan JK. 1998. Demographic diversity and faultlines: the compositional dynamics of organizational groups. *Academy of Management Review* **23**: 325-340.
Lo EHS, Au A, Hoek PJ, Eberl L. 2011. Analysis of evolving team interactions in dynamic targeting. *International Journal of Intelligent Defence Support Systems* **4**: 309-327.
Locke EA, Latham GP. 1990. *A Theory of Goal Setting and Task Performance*. Prentice Hall: Englewood Cliffs, NJ.
Marks MA, Mathieu JE, Zaccaro SJ. 2001. A temporally based framework and taxonomy of team processes. *Academy of Management Review* **26**: 356–376.
McComb SA. 2008. Shared mental models and their convergence. In *Macrocognition in Teams: Theories and Methodologies*, Letsky MP, Warner NW, Fiore SM, Smith CAP (eds). Ashgate Publishing: Burlington, VT; 35–50.
McComb SA, Kennedy DM. 2012. Facilitating effective mental model convergence: the interplay among the team's task, mental model content, communication flow, and media. In *Theories of Team Cognition: Cross-Disciplinary Perspectives*, Salas E, Fiore S, Letsky M (eds). Routledge Academic: New York, NY; 549–568.
Miller JH, Page SE. 2007. *Complex Adaptive Systems*. Princeton University Press: Princeton, NJ.
Milliken FJ, Martins LL. 1996. Searching for common threads: understanding the multiple effects of diversity in organizational groups. *Academy of Management Review* **21**: 402–433.
Mohammed S, Dumville BC. 2001. Team mental models in a team knowledge framework: expanding theory and measurement across disciplinary boundaries. *Journal of Organizational Behavior* **22**: 89–106.
Mohammed S, Ferzandi L, Hamilton K. 2010. Metaphor no more: a 15-year review of the team mental model construct. *Journal of Management* **36**: 876–910.
Molinsky A. 2007. Cross-cultural code-switching: the psychological challenges of adapting behavior in foreign cultural interactions. *Academy of Management Review* **32**: 622–640.
Molloy JC, Ployhart RP, Wright PM. 2011. The myth of "the" micro–macro divide: bridging system-level and disciplinary divides. *Journal of Management* **37**: 581–609.
Morgeson FP, Hofmann DA. 1999. The structure and function of collective constructs: implications for multilevel research and theory development. *Academy of Management Review* **24**: 249–265.
Nicolis G, Prigogine I. 1989. *Exploring Complexity*. W. H. Freeman: New York.
Ostroff C, Bowen DE. 2000. Moving HR to a higher level: HR practices and organizational effectiveness. In *Multilevel Theory, Research and Methods in Organizations: Foundations, Extensions, and New Directions*, Klein KJ, Kozlowski SWJ (eds). Jossey-Bass: San Francisco, CA; 211–266.
Pearce M, Rentch TA, Kozlowski SWJ, DeShon RP, Braun MT, Baard SK. 2011. Antarctic teams research report. Department of Psychology, Michigan State University, East Lansing, MI.
Ployhart RE. 2012. Personnel selection: ensuring sustainable organizational effectiveness through the acquisition of human capital. In *The Oxford Handbook of Organizational Psychology*, Kozlowski SWJ (ed). Oxford University Press: New York; 221–246.
Ployhart RE, Moliterno TP. 2011. Emergence of human capital resource: a multilevel model. *Academy of Management Review* **36**: 127–150.
Ployhart RE, Weekley JA, Ramsey J. 2009. The consequences of human resource stocks and flows: a longitudinal examination of unit service orientation and unit effectiveness. *Academy of Management Journal* **52**: 996–1015.
Rentsch JR, Delise LA, Hutchinson S. 2008. Transferring and developing cognitive similarity in decision-making teams: collaboration and meaning analysis process. In *Macrocognition in Teams: Theories and Methodologies*, Letsky MP, Warner NW, Fiore SM, Smith CAP (eds). Ashgate Publishing: Burlington, VT; 127–142.
Reynolds CW. 1987. Flocks, herds, and schools: a distributed behavioral model. *Computer Graphics* **21**: 25–34. (SIGGRAPH '87 Conference Proceedings).
Roberts KH, Hulin CL, Rousseau DM. 1978. *Developing an Interdisciplinary Science of Organizations*. Jossey-Bass: San Francisco.
Robinson WS. 1950. Ecological correlations and the behavior of individuals. *American Sociological Review* **15**: 351–357.
Rousseau DM. 1985. Issues of level in organizational research: multi-level and cross-level perspectives. In *Research in Organizational Behavior*, Cummings LL, Staw BM (eds). JAI Press: Greenwich, CT; **7**: 1–37.
Simon HA. 1973. The organization of complex systems. In *Hierarchy Theory*, Pattee HH (ed). Braziller: New York; 1–27.
Stasser G, Titus W. 1985. Pooling of unshared information in group decision making: biased information sampling during discussion. *Journal of Personality and Social Psychology* **48**: 1467–1478.
Steiner ID. 1972. *Group Process and Productivity*. Academic Press: New York.
Stevens RH, Galloway T *et al*. 2009. Can neurophysiologic synchronies provide a platform for adapting team performance? *Human Computer Interaction International*, San Diego, CA.
Stewart K. 2005. Cultural poesis: the generativity of emergent things. In *The Sage Handbook of Qualitative Research* (3rd edn), Denzin NK, Lincoln YS (eds). Sage: Thousand Oaks, CA; 1027–1042.

DOI: 10.1002/mde

Thorndike EL. 1939. On the fallacy of imputing the correlations found for groups to the individuals or smaller groups composing them. *The American Journal of Psychology* **52**: 122–124.

Tsui AS, Egan TD, O'Reilly CA. 1992. Being different: relational demography and organizational attachment. *Administrative Science Quarterly* **37**: 547–579.

Turner JC, Oakes PJ, Haslam SA, McGarty C. 1994. Self and collective: cognition and social context. *Personality and Social Psychology Bulletin* **20**: 454–463.

Van Iddekinge C, Ferris GR, Perrewe PL, Perryman AZ, Blass FR, Heetderks TD. 2009. Effects of selection and training on unit-level performance over time: a latent growth modeling approach. *Journal of Applied Psychology* **94**: 829–843.

Van Maanen J. 2010. A song for my supper: more tales of the field. *Organizational Research Methods* **13**: 240–255.

Van Maanen J. 2011. *Tales of the Field: On Writing Ethnography* (2nd edn). University of Chicago Press: Chicago.

Wegner DM, Giuliano T, Hertel P. 1985. Cognitive interdependence in close relationships. In *Compatible and Incompatible Relationships*, Ickes WJ (ed). Springer-Verlag: New York; 253–276.

DOI: 10.1002/mde