2026
Volume 7
Article 75
https://doi.org/10.20851/ll.v7.75

Learner agency across scales: An integrative perspective on self-regulated learning in algorithmically mediated environments

Paula G. de Barba[1]

[1] Monash Education Academy, Monash University, Australia

As digital and AI-mediated systems increasingly capture data about learners and use it to make decisions about how their learning is supported, questions of human agency become central. Self-regulated learning (SRL) provides a multidimensional account of how learners take control of their development. Yet although foundational SRL models attended to learners' broader life concerns, the field has progressively narrowed to task-focused regulation, and its dominant operationalisation in educational technology has narrowed further still, to behavioural proxies amenable to data-driven intervention. This paper proposes an integrative perspective that extends SRL by connecting it with two adjacent theoretical perspectives: complex systems science and Freirean critical pedagogy. The perspective foregrounds three dimensions of agency: regulation, integration, and positioning. Together they describe a learner who is not merely responsive to learning environments but capable of understanding and acting on the structural conditions shaping their experience. A cross-scale scaffold is presented: a design orientation that supports learners to move between regulation within immediate tasks, integration of patterns across their educational trajectory, and positioning in relation to the structural conditions of their learning. This perspective contributes a theoretical integration across SRL, critical pedagogy, and learning analytics that has until now remained disconnected.

Keywords: complex systems science, critical pedagogy, educational technology, learner agency, learning analytics, self-regulated learning.

Corresponding author: Paula G. de Barba, paula.debarba@monash.edu

Recommended citation: de Barba, P. G. (2026). Learner agency across scales: An integrative perspective on self-regulated learning in algorithmically mediated environments. *Learning Letters*, 7, Article 75. https://doi.org/10.20851/ll.v7.75

Submitted: 01/05/2026
Accepted 07/07/2026
Published: 12/08/2026

Introduction

As digital and AI-mediated systems become more pervasive in education, questions of human agency become central. Algorithmically mediated learning environments have the ability to datafy students' behaviours and achievements, and pair them with systems that classify, predict, and recommend (van Dijck, 2014), reshaping the conditions under which learners can exercise agency. Self-regulated learning (SRL) theory has long positioned the learner as an active agent in their own development (Zimmerman, 2000). It is a multidimensional account that integrates cognition, motivation, affect, behaviour, and context (Pintrich, 2004). Yet two limitations have constrained its usefulness for understanding learner agency in algorithmically mediated learning environments.

First, the scope of the SRL field has progressively narrowed to task-focused regulation, leaving broader life conditions, identities, structural positions, and wider trajectories under-theorised. Second, the operationalisation of SRL in educational technology has narrowed the construct further still. Its multidimensional richness has been collapsed into optimisable behaviours such as time management, strategy use, and effort allocation, which are measured, predicted, and adjusted through system-generated feedback (Matcha et al., 2019; Molenaar, 2022). What is missing is an account of learner agency that retains SRL's sophistication while extending its scope to the relational, contextual, and critical dimensions of learning in such environments. In this paper, learner agency refers to the capacity to act with intention in relation to one's own learning across multiple scales: regulating engagement within tasks, integrating experience across contexts and time, and positioning oneself critically in relation to the conditions that frame what learning is and can become. Learner agency, in this view, is neither a fixed individual attribute nor a property of systems acting on the learner, but an emergent capacity (Code, 2020) cultivated through the relationship between learner and conditions.

This paper proposes an integrative perspective that connects SRL with two adjacent theoretical perspectives: complex systems science and Freirean critical pedagogy. These describe a learner who is not merely responsive to systems but capable of interpreting, navigating, and shaping the conditions of their own learning. The perspective foregrounds three dimensions of learner agency: regulation, integration, and positioning. These form a cross-scale scaffold, a design orientation supporting learners as they move critically between the dimensions rather than directing them toward predefined behaviours.

The scope and operationalisation of SRL

SRL describes the processes by which individuals take control of their own learning: setting goals, monitoring progress, adapting strategies, and evaluating outcomes (Pintrich, 2004; Zimmerman, 2000). Within social cognitive theory, this regulatory cycle expresses human agency; that is, the capacity to initiate, direct, and reflect on one's own actions in pursuit of valued goals (Bandura, 2001). SRL is more than a set of study skills; it is a theory of how people exercise deliberate control over their learning, integrating cognitive, motivational, behavioural, and contextual dimensions into a coherent framework.

Two limitations have shaped SRL's usefulness for theorising learner agency in algorithmically mediated environments: one of scope, one of operationalisation. The scope limitation is one of progressive narrowing. Foundational models attended to learners' well-being alongside task performance (Boekaerts, 1999) and explicitly identified context as one of four regulatory domains (Pintrich, 2004). Yet the dominant strand of SRL research, the task-focused empirical programme and its operationalisation in learning analytics, has come to centre on the learning task as the unit of analysis, with context's regulatory significance receiving less sustained attention. What this leaves harder to address is how the conditions of learning (e.g. platforms, metrics, feedback systems, institutional structures) shape what the learner can become, and how learners might exercise agency over those conditions rather than only within them.

This narrowing is not an absence of context in SRL theory. Winne and Hadwin's (1998) COPES model builds task conditions into its architecture as inputs that shape every regulatory operation, and Pintrich's (2004) regulation of context licenses learners to adjust their immediate environment. In each case, however, context enters as a condition to be monitored, adapted to, or locally adjusted in service of the learner's goals. Conditions are manageable and standards are the criteria against which products are evaluated; neither is positioned as an object of critique. The distinction developed in this paper is therefore not between models that include context and models that do not, but between agency exercised within conditions, adjusting oneself or one's immediate environment toward a given goal, and agency exercised

over conditions, questioning what those conditions measure, whose purposes they encode, and whether they might be changed. This boundary is not an oversight but a matter of explanatory scope: SRL theorises goal attainment, not goal critique.

The operationalisation limitation is related to how learning analytics systems predominantly operationalise SRL through observable behavioural proxies (e.g., session frequency, resource access, submission timing) used to classify, predict, and intervene in students' learning (de Barba et al., 2020; Matcha et al., 2019). This approach has enabled personalised support at scale, yet it positions the learner as the subject of the system's intelligence rather than an agent exercising their own. The learner's data becomes an object of analysis; what the learner does with the meaning of that data remains largely outside the system's concern.

These narrowing trajectories have not gone unnoticed. Critical scholars have argued that the dominant operationalisation of SRL aligns with neoliberal frameworks that position learners as self-optimising subjects responsible for their own performance, while obscuring the structural conditions shaping those outcomes (Selwyn, 2019). Critical learning analytics scholarship has further argued that learners should be understood as active agents in relation to their own data (Prinsloo & Slade, 2014), and that algorithmic systems encode assumptions about what learning is and who succeeds, often without making those assumptions available for scrutiny (Selwyn, 2019). Yet these critical perspectives have developed largely in isolation from SRL theory, leaving the regulatory framework without a language for structural critique and that body of scholarship without a model of how regulation works.

A related challenge has emerged with generative AI. As Lodge et al. (2023) argued, framing learner preparation around AI literacy alone is insufficient. What is needed is an understanding of the self as the organising centre of a distributed network of regulation. Within this network, learners navigate between machines, peers, teachers, and institutional structures while remaining responsible for integrating these experiences meaningfully. The challenge is not to make learners more responsive to intelligent systems, but to ensure those systems expand learners' capacity to understand and direct their own learning.

An integrative perspective: Three dimensions of learner agency

This paper proposes three integrated dimensions of learner agency: regulation, integration, and positioning (Figure 1). Each is grounded in a distinct theoretical perspective; together, they extend SRL toward an account that is contextual, relational, and critical.

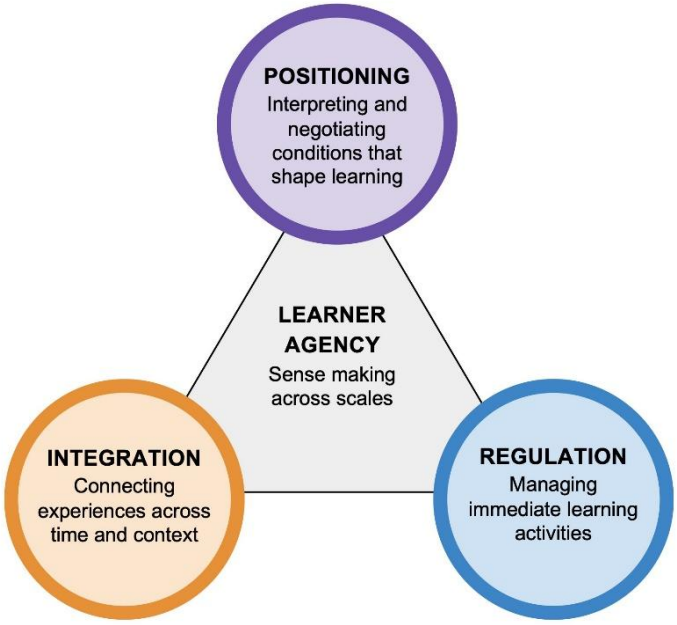
Regulation: The self as an active managing process

The regulatory dimension draws on social cognitive SRL theory (Bandura, 2001; Zimmerman, 2000). Within any learning activity, regulation is distributed across people and tools: goals are negotiated, standards are made visible, monitoring and evaluation are shared (Hadwin et al., 2011; Lodge et al., 2023). Self-regulation and co-regulation are not opposites. Regulation can be relational in the moment without dissolving the learner's agency, and what changes across time is the degree to which the learner internalises regulatory processes as their own (Hadwin et al., 2011; McCaslin, 2009). This dimension is well-supported by existing SRL theory and educational technology. From within SRL research, its boundaries appear as a matter of analytical focus. That focus has consequences: regulation alone produces an incomplete picture of agency, inadequate precisely when learners must understand and act on the conditions shaping their learning. A student who notices their attention drifting and moves to a quieter space is regulating within the task. The same student who recognises that this difficulty recurs across every late-afternoon session and treats it as a pattern rather than a series of isolated lapses has begun to move beyond regulation toward integration.

Integration: The self as an organising centre across time and contexts

The integration dimension draws on complex systems science (Mitchell, 2009) and developmental accounts of learning. Learning does not occur in single activities; the experience unfolds across time, accumulates across contexts, and is carried forward by the learner (de Barba et al., 2015; van Geert, 2019). From a complex systems perspective, regulatory processes are not stable traits applied consistently across situations but emergent patterns arising from dynamic interaction between a learner and their context (Mitchell, 2009). This dimension foregrounds the learner as the organising centre, the agent who gives meaning to experience across contexts rather than the subject whose patterns are identified by a system. A learner who connects a struggle in one course to a similar experience in another and recognises a recurring relationship between how a subject is taught and how well they engage is doing integrative work that no single task captures. Learner agency here is not a fixed attribute to be measured but an emergent property to be cultivated through the conditions of learning.

Figure 1: Three dimensions of learner agency.



Positioning: The self as a critical interpreter

The positioning dimension draws centrally on Freirean critical pedagogy. Freire (1970) argued that authentic education begins with *conscientização*, or the development of critical consciousness: the capacity to name and problematise the conditions of one's experience rather than simply adapting to them. A parallel body of scholarship within educational technology has interrogated how digital systems and learning analytics shape what learning is taken to be (Selwyn, 2019). Both bodies of work have remained largely separate from SRL. One exception is the recent work that brings critical consciousness together with a social cognitive account of agency for algorithmically mediated contexts (Code, 2020, 2025); this work elaborates modes of agency rather than the scales of agency. Critical educational technology scholarship, meanwhile, has not been connected to a model of how regulation works. The integrative perspective developed here makes critical positioning a dimension of

regulation itself, rather than a parallel process.

In algorithmically mediated learning, this means recognising that the environments in which learning occurs are not neutral. They encode assumptions about what counts as engagement, who is a successful learner, and what learning is for. In learning analytics systems, these assumptions are embedded in design: in the metrics chosen, the thresholds that define risk, and the feedback models that recommend actions, often without making those values visible (Prinsloo & Slade, 2014). Supporting agency in such environments requires that learners develop the capacity to interpret what their data reflects, question what it does not capture, and act on that interpretation. This includes advocating for different conditions where current ones constrain their development. A student who monitors their study time has regulatory awareness. Consider instead a student whose learning happens largely through offline reading and handwritten notes, and whom the dashboard classifies as disengaged because engagement is operationalised as platform activity. Recognising the mismatch is interpretive work; acting on it might mean raising the operationalisation with their teacher, offering other evidence of their learning, or discounting the dashboard signal in their own self-evaluation. That combination of recognition and response is an expression of critical learning agency.

Yet naming three dimensions is not the same as showing how a learner moves between them. Regulation, integration, and positioning describe distinct capacities, but agency in practice lies in their coordination, which is the problem the next section takes up.

A cross-scale scaffold for learner agency: Connecting the dimensions

The three dimensions describe distinct capacities, but agency emerges in the movement between them rather than in any one alone. Supporting that movement is a design challenge. Critical scholarship in educational technology has identified problems with how analytics systems frame, measure, and intervene in learning, proposing design responses from transparency and contestability to value-sensitive and participatory approaches (Prinsloo & Slade, 2014; Selwyn, 2019). The contribution offered here does not replicate these but adds a complementary one, grounded in the integrative perspective developed above. This is a cross-scale scaffold whose function is to support the learner in moving between the three dimensions of agency, with their own sensemaking as the connecting thread.

Agency, on this account, operates at multiple scales. Scale is used here to mean nested extents of time and social organisation, from the immediate task through the learner's trajectory to the structural conditions of their education; level is retained only when reporting others' terminology. Drawing on complex systems science (Mitchell, 2009), patterns at one scale (a single task, a course) emerge from and feed into dynamics at others (a learner's developing identity). Agency is therefore exercised not at a single scale but in the movement between them: a learner might zoom out from a moment of difficulty to ask whether it reflects a recurring pattern, zoom further out to ask whether the conditions framing it are negotiable, and zoom back in to act on what those wider scales reveal.

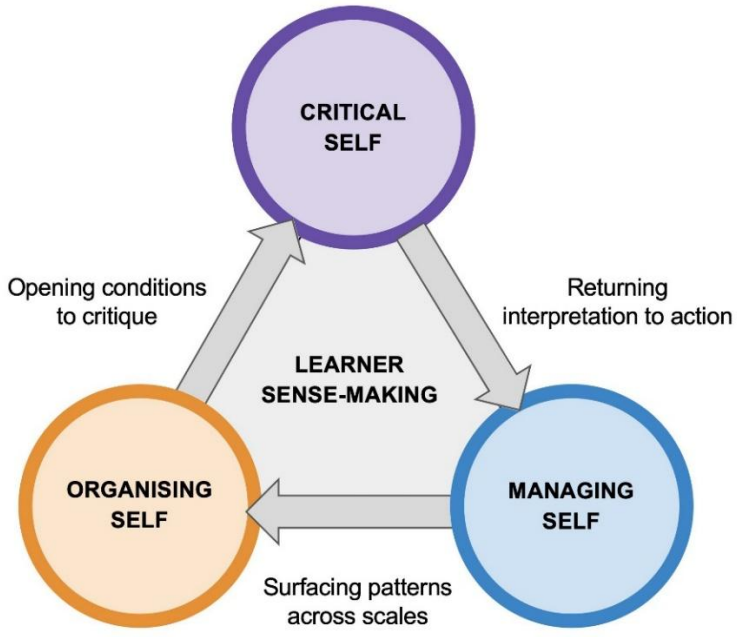
This view resonates with adjacent theoretical perspectives. Bronfenbrenner's (1979) ecological systems theory grounded human development in nested system levels (micro-, meso-, exo- and macrosystems) and learning sciences scholarship has examined how processes at different timescales and levels of analysis shape one another in educational settings (Lemke, 2000). What complex systems science adds, and what is taken up here, is the dynamic character of cross-scale relations: structures and processes at different scales mutually constitute one another, with no scale fully reducible to or determined by another. This paper defines a cross-scale scaffold as the design of supports that operate across and through interactions between nested scales, so that processes at one scale can dynamically shape,

and are shaped by, others. Its function in learning is fully achieved only when students become agents of their own connection across these scales.

Existing systems predominantly operate at a single scale, leaving the learner without support for cross-scale movement. The scaffold is a design orientation, not a feature set, in which four functions become central (Figure 2):

1. **Surfacing patterns across scales.** When a learner observes a regulatory signal within a task (e.g., disengaging during timed quizzes) the system should support them in asking whether this is situational or part of a wider pattern across their trajectory. This connects regulation to integration, treating individual data points as occasions for cross-context interpretation rather than isolated signals.
2. **Opening conditions to critique.** Once a pattern is recognised (e.g., that timed quizzes consistently measure speed more than the understanding the learner has built), the system should support the learner in asking whether it reflects something they wish to change in themselves, or conditions of the environment that might be negotiated, such as with teachers, with institutions, or in their own arrangements. This connects integration to positioning, opening the space in which structural conditions become available for critique.
3. **Returning interpretation to action.** Critical awareness without a path back to action risks paralysis. The system should support the learner in translating wider-scale insights into local action; for example, raising the quiz format with an instructor, adjusting how they prepare, or revising what the score signals about their learning. This closes the loop, returning positioning and integration to regulation on more informed terms.
4. **Centring the learner as the agent of connection.** The system surfaces the quiz-engagement signal but does not decide what it means or whether the format warrants critique; it makes connections available for the learner to make. The learner's sensemaking is the connective tissue; the scaffold supports this work without doing it for them.

Figure 2: Cross-scale scaffold for learner agency.



These functions extend rather than replace existing critical educational technology proposals. What the cross-scale scaffold adds is a focus on the learner's movement between scales: the agentic work that joins regulation, integration, and positioning into a coherent practice.

Discussion and conclusion

The perspective developed here extends SRL theory for understanding and supporting learner agency in algorithmically mediated environments. Its core claim is that regulation (i.e., planning, monitoring, adapting) is necessary but insufficient: agency also requires integrating experience across time and context, and positioning oneself critically in relation to the environments one inhabits. Grounded in social cognitive SRL, complex systems science, and Freirean critical pedagogy, these three dimensions describe a learner who is not merely a user of learning systems, but an agent engaged in understanding and shaping the conditions of their development.

Adjacent theoretical perspectives have approached this integration but not completed it. While SRL theory provides a sophisticated model of regulatory processes, task-focused research and its applications have remained oriented toward performance within conditions rather than critique of them. Critical pedagogy (Freire, 1970) has foregrounded the importance of questioning the structural conditions of learning but lacks a regulatory architecture. Recent frameworks integrating critical orientation with social cognitive agency in postdigital contexts (Code, 2020, 2025) supply that architecture and expand the modes through which agency is distributed, but do not theorise agency across nested scales or the learner's movement between them. Critical scholarship in learning analytics (Prinsloo & Slade, 2014; Selwyn, 2019) has raised crucial questions about student data agency and algorithmic power but has not connected these to a model of regulation. Bringing these conversations together opens possibilities that each perspective has been unable to realise alone.

As AI systems take on increasingly active roles in mediating learning (e.g., generating feedback, recommending resources, simulating interlocutors) the question of what learner agency means becomes urgent (Lodge et al., 2023). The cross-scale scaffold offers a design-level response grounded in a coherent account of agency, focused on supporting the learner's movement between scales rather than optimising behaviour at any single one.

For research, this perspective generates testable questions. What scaffold features support learners' movement between regulation, integration, and positioning? How do positioning capacities develop in different system contexts? How do the three dimensions interact across scales, and what conditions support their integration? These questions extend current SRL research agendas in directions that existing frameworks have not yet addressed.

Producing genuinely agentic learners is a central educational challenge of our time. Such learners are equipped not only to manage their cognition, motivation, affect and behaviour within systems, but to question the conditions of their participation, including the goals those conditions encode. This perspective offers a theoretical foundation for educational technology that places human agency, in its fullest sense, at the centre.

Funding

No funding was received for the conduct of this research.

Disclosure of conflicts of interest

The author(s) report(s) no potential conflict of interest.

Disclosure of the use of AI-assisted technologies during writing

The author used Claude (Anthropic) for editorial and structural assistance throughout all sections in the article, including this one. The author takes full responsibility for the content.

About the author

Paula de Barba is a Senior Lecturer at Monash University, Australia, in the Monash Education Academy. Paula's research focuses on self-regulated learning, with a particular emphasis on the interplay between students' cognitive, emotional and motivational factors in digitally mediated environments. Her work has moved progressively outward in scale, from within-session studies of motivation and participation, to learning across subjects and courses in higher education – a trajectory that led to the cross-scale perspective developed here.

ORCID: https://orcid.org/0000-0001-5586-6619

References

Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual Review of Psychology, 52*, 1–26. https://doi.org/10.1111/1467-839X.00024

Boekaerts, M. (1999). Self-regulated learning: Where we are today. *International Journal of Educational Research, 31*(6), 445–457. https://doi.org/10.1016/S0883-0355(99)00014-2

Bronfenbrenner, U. (1979). *The ecology of human development: Experiments by nature and design*. Harvard University Press.

de Barba, P., Ainley, M. D. & Kennedy, G. (2015). The trajectory of situational interest in an online learning session. In *Proceedings of the American Educational Research Association Annual Meeting*. Chicago, IL, USA.

de Barba, P. G., Malekian, D., Oliveira, E. A., Bailey, J., Ryan, T., & Kennedy, G. (2020). The importance and meaning of session behaviour in a MOOC. *Computers & Education, 146*, 103772. https://doi.org/10.1016/j.compedu.2019.103772

Code, J. (2020). Agency for learning: Intention, motivation, self-efficacy and self-regulation. *Frontiers in Education, 5*, 19. https://doi.org/10.3389/feduc.2020.00019

Code, J. (2025). The entangled learner: Critical agency for the postdigital era. *Postdigital Science and Education, 7*, 336-358. https://doi.org/10.1007/s42438-025-00544-1

Freire, P. (1970). *Pedagogy of the oppressed*. Continuum.

Hadwin, A. F., Järvelä, S., & Miller, M. (2011). Self-regulated, co-regulated, and socially shared regulation of learning. In B. J. Zimmerman & D. H. Schunk (Eds.), *Handbook of self-regulation of learning and performance* (pp. 65–84). Routledge.

Lemke, J. L. (2000). Across the scales of time: Artifacts, activities, and meanings in ecosocial systems. *Mind, Culture, and Activity, 7*(4), 273–290. https://doi.org/10.1207/S15327884MCA0704_03

Lodge, J. M., de Barba, P. G., & Broadbent, J. (2023). Learning with generative artificial intelligence within a network of co-regulation. *Journal of University Teaching and Learning Practice, 20*(7), 1–10. https://doi.org/10.53761/1.20.7.02

Matcha, W., Gašević, D., & Pardo, A. (2019). A systematic review of empirical studies on learning analytics dashboards: A self-regulated learning perspective. *IEEE Transactions on Learning Technologies, 13*(2), 226–245. https://doi.org/10.1109/TLT.2019.2916802

McCaslin, M. (2009). Co-regulation of student motivation and emergent identity. *Educational*

Psychologist, 44(2), 137–146. https://doi.org/10.1080/00461520902832384

Mitchell, M. (2009). *Complexity: A guided tour*. Oxford University Press.

Molenaar, I. (2022). The concept of hybrid human-AI regulation: Exemplifying how to support young learners' self-regulated learning. *Computers and Education: Artificial Intelligence, 3*, 100070. https://doi.org/10.1016/j.caeai.2022.100070

Pintrich, P. R. (2004). A conceptual framework for assessing motivation and self-regulated learning in college students. *Educational Psychology Review, 16*(4), 385–407. https://doi.org/10.1007/s10648-004-0006-x

Prinsloo, P., & Slade, S. (2014). Educational triage in open distance learning: Walking a moral tightrope. *International Review of Research in Open and Distributed Learning, 15*(4), 306–331. https://doi.org/10.19173/irrodl.v15i4.1881

Selwyn, N. (2019). What's the problem with learning analytics? *Journal of Learning Analytics, 6*(3), 11–19. https://doi.org/10.18608/jla.2019.63.3

van Dijck, J. (2014). Datafication, dataism and dataveillance: Big Data between scientific paradigm and ideology. *Surveillance & Society, 12*(2), 197–208. https://doi.org/10.24908/ss.v12i2.4776

van Geert, P. L. (2019). Dynamic systems, process and development. *Human Development, 63*(3–4), 153–179. https://doi.org/10.1159/000503825

Winne, P. H., & Hadwin, A. F. (1998). Studying as self-regulated learning. In D. J. Hacker, J. Dunlosky & A. C. Graesser (Eds.), *Metacognition in educational theory and practice* (pp. 277–304). Lawrence Erlbaum Associates.

Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts & P. R. Pintrich (Eds.), *Handbook of self-regulation* (pp. 13–39). Academic Press.