# Chapter X
# A New Paradigm for Research Organization: Academic Leadership in Transdisciplinary Science Teams

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## Objectives

- To create an understanding of the role of academic leaders in transdisciplinary science.
- To shed light on the challenges for transdisciplinary science in the context of new research collaborations.
- To assess leadership actions and activities from the perspective of complexity leadership theory.
- To demonstrate how leadership practices can lead to top-down rather than bottom-up knowledge creation processes.
- To emphasize the importance of placing knowledge brokers and hybrid researchers in strategic leadership positions at different organizational levels.

## Introduction to the Chapter

Prior research has shown that leadership plays a key role in knowledge-producing organizations and their efforts to create innovative discoveries. Yet, we know very little of leadership in the context of transdisciplinary science. This chapter reports on a longitudinal qualitative case study where the author examined the kind of leadership roles and practices academic leaders draw on when seeking to promote emerging transdisciplinary collaboration in a complex adaptive system (Mäkinen, 2018a). Complex adaptive systems are places for actors to engage in knowledge-intensive cooperation in a collaborative network that has a common goal (e.g., Hazy, 2007; Marion & Uhl-Bien, 2001; Uhl-Bien, Marion & McKelvey, 2007). Transdisciplinary research organizations are like complex adaptive systems, because they bring together actors from varied backgrounds, promote interdependence among them, and form dynamic collectives with common goals (Cilliers, 1998; Lotrecchiano, 2010; Marion, 1999).

The empirical analysis presented in this chapter shows how academic leaders addressed these kinds of challenges and supported transdisciplinary collaboration in a newly formed transdisciplinary research organization. The research center was formed through a partnership between a School of Medicine and a non-profit foundation. It brought together physicians, medical researchers, and scientists from different fields to study a specific problem,

premature birth. Despite decades of research on premature birth, the problem remains unsolved. Premature birth is an <mark>adaptive challenge</mark>: solving it requires new learning, innovation, and new patterns of behavior (Heifetz, 1994; Heifetz & Linsky, 2002).

This chapter focuses on analyzing the role of the leaders of transdisciplinary science. The findings demonstrate that when it comes to attracting researchers from different disciplinary backgrounds to advance knowledge on a single research problem collaboratively, the leaders of transdisciplinary science must rely on different leadership roles and practices. The leaders first drew on practices related to enabling leadership: they modelled transdisciplinary behavior and took on roles as knowledge translators and brokers (Hazy & Uhl-Bien, 2013, Uhl-Bien et al., 2007; Mäkinen et al., 2019). While brokering and bridging practices often support innovation (Lomas, 2007; Ward, House, & Hamer, 2009; Waring, Currie, Crompton, & Bishop, 2013), these activities began to reinforce administrative leadership and made the leaders the focal point of transdisciplinary knowledge integration. This hindered the creation of shared <mark>adaptive dynamics</mark>.

## Background

Transdisciplinary research collaborations have developed at such an increasing rate that researchers interested in how they should be managed have had a difficult time keeping up. Transdisciplinary science aims at solving complex problems, crossing disciplinary boundaries, including different stakeholders in the research process, and enhancing the practical value of findings (Klein, 2014; Maasen & Lieven, 2006). The multidisciplinary, collaborative, and multi-organizational nature of transdisciplinary research calls for academic leadership that is able to nurture collaboration across different kinds of knowledge boundaries (Shrum, Genuth, & Chompalov, 2007; Sonnenwald, 2007).

In the context of non-academic organizations, leadership researchers have declared that the relationships between leaders and organizational members matter for how organizations perform (Barge & Musambira, 1992). Moreover, both theoretical and empirical contributions in leadership research have demonstrated that leadership plays a key role in knowledge creation processes in non-academic organizations (Bryant, 2003; Lakshman, 2007; Politis, 2002; Srivastava, Bartol, & Locke, 2006). Yet, the role of leaders in institutions of higher education has attracted little empirical attention (Bryman, 2007).

Those leading transdisciplinary research in academic contexts face particular challenges. First, cross-disciplinary research units are different from discipline-based departments. Biancani, McFarland, and Dahlander (2014) defined interdisciplinary research centers as semiformal organizations that are temporary and fluid, and where participation is voluntary. The authors argued that university departments, in comparison, are formal units where organizational memberships are assigned as a term of employment. These disciplinary and departmental communities offer their members safety, familiarity, and a clear understanding of academic norms (Abbott, 2001). Instead, transdisciplinary collaboration requires that scholars view knowledge creation beyond their disciplinary units and consider the goals of a broader knowledge system (Klein, 1990). Therefore, leaders of transdisciplinary science have to attract scholars from departmental to transdisciplinary units and support their voluntary participation in the shared, transdisciplinary research endeavor.

| **Challenge 1:** Promoting participation | **Example:** Schmidt and Pröpper (2017) studied an international multi-institutional collaboration dealing with sustainable land management in Angola, Botswana, and Namibia. Participation in the transdisciplinary effort, team-building, and generation of shared goals were challenged by varied incentive structures, roles, and responsibilities in the participants' home institutions. |
| --- | --- |

Once leaders of transdisciplinary science have succeeded in attracting talented scholars across departments, they face another leadership challenge: how to motivate scholars to interact across disciplinary boundaries. Some have conceptualized this challenge as one of cognitive incommensurability (Cummings & Kiesler, 2005; Dougherty, 1992; Lamont, 2009; Murray, 2010). Collaborators' different disciplinary orientations, motivations, and professional interests can come in the way of collaboration. These challenges are highlighted in transdisciplinary science, because it brings together not only academics from different disciplines, but also non-academic actors, such as practitioners, policymakers, and industry representatives, who all have their own reasons to participate (Klein, 2014; Maasen & Lieven, 2006).

| **Challenge 2:** Communication across fields and interests | **Example:** A study by Suldovsky, McGreavy, and Lindenfeld (2018) analyzed communication in the context of a transdisciplinary project focusing on strengthening decision making for beach and shellfish flat management in Maine and New Hampshire. Collaborative communication was challenging, if not impossible, due to the collaborators' internalized epistemic authority of particular forms of knowledge production. |
| --- | --- |

As a third challenge, after researchers are in place and collaborating in the transdisciplinary research organization, leaders of transdisciplinary science have to manage the tension between the need to innovate and the need to produce (Uhl-Bien & Arena, 2018). In order to survive, complex adaptive systems, such as transdisciplinary research organizations, have to produce innovative knowledge rapidly (Uhl-Bien et al., 2007). The creation of innovative outcomes requires risk taking, experimentation, and play (March, 1991). This can create a tension in a transdisciplinary research organization, because the familiar disciplinary research approach may appear as a faster path to productivity (Mäkinen et al., 2019). In relation to their work on leadership and organizational adaptability, Uhl-Bien and Arena (2018) have noted that it is important not to let "the pressure to produce overwhelm the need to innovate" (p. 11). Leaders of transdisciplinary science, then, need to make sure that scholars do not fall back on their disciplinary ways of creating knowledge when there is pressure to produce outcomes.

| | |
|---|---|
| **Challenge 3:** Producing transdisciplinary outcomes | **Example:** Pohl (2005) studied two transdisciplinary environmental research programs that sought to promote collaboration between social and natural scientists. The pressure to produce results led to a division of labor among the social and natural scientists, where they remained in and took responsibility for their own disciplinary areas, instead of engaging in transdisciplinary collaboration. |

The next section gives an overview of the complexity leadership theory. It is followed by a description of the empirical setting, data collection, and data analysis. When reporting on findings from the longitudinal qualitative case study, I explain the different roles and practices the leaders relied on when mobilizing transdisciplinary collaboration and seeking to overcome the previously discussed challenges (Mäkinen, 2018a). Finally, the chapter concludes with a discussion on what complexity leadership theory can add to our understanding of transdisciplinary science and the role of academic leaders.

## Conceptualizing Leadership in Transdisciplinary Science

Organizations focusing on knowledge-intensive work and outcomes operate in an increasingly fast-paced environment, where traditional leadership models, often bureaucratic and centralized in nature, are insufficient (Marion & Uhl-Bien, 2001; Schneider & Somers, 2006). Scholars have questioned the extent to which traditional leadership models can support modern organizations, where the main purpose is to create innovative products by combining the expertise of different individuals. As a result, leadership researchers have begun to consider leadership as practices distributed throughout the organization rather than as actions of a few leaders at the top-level of the organization (Hargadon, 2003; Pearce & Sims, 2000; Yukl, 2005). Figure 1 demonstrates the changes in leadership models over the course of the last century (Lotrecchiano, 2019). Instead of leader-centrism, leadership models have become aligned with systems thinking. The new theories also emphasize a relational kind of leadership that focuses on dynamic and interactive social processes occurring throughout the organization (Drath, 2001; Uhl-Bien, 2006).

Figure 1. Typology of Leadership Models in the Twentieth Century: From Leader-Centrism to Systems-Centrism (Lotrecchiano, 2019)
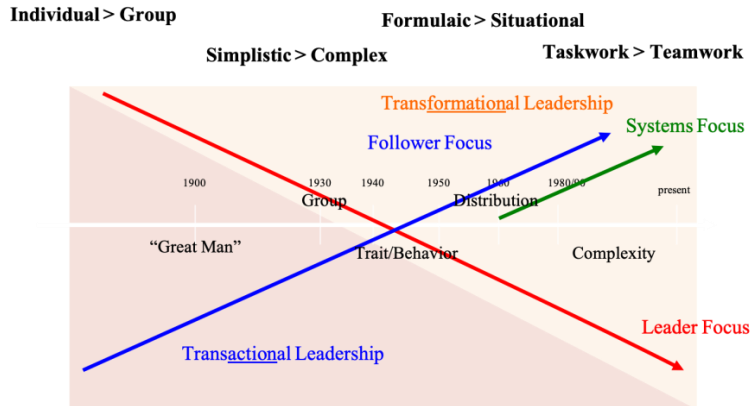
Building on this work, scholars have developed new conceptualizations of leadership that are grounded in complexity theory (Hazy, 2007; Lichtenstein et al., 2006; Marion & Uhl-Bien, 2001; Uhl-Bien et al., 2007). Complexity leadership theory emerged from the idea that a nuanced understanding of leadership in the Knowledge Era is needed (Marion & Uhl-Bien, 2001). In such a context, leadership is dynamically evolving, emergent, and distributed (Bolden, 2011; Dervitsiotis, 2005). Uhl-Bien et al. (2007) defined the complexity leadership theory model as "connective, distributed, dynamic, and contextual" (p. 302). The purpose of this research has been to understand what leadership means in knowledge-intensive complex adaptive systems, where individuals collaborate and share a common goal.

## *Complexity Leadership Theory: Roles and Practices*

Complexity leadership theory perceives leadership as an interplay between many forces: administrative, enabling, and adaptive leadership (Marion & Uhl-Bien, 2001; Uhl-Bien et al., 2007). In order to create effective adaptive dynamics—*that is, the generation of creative knowledge, that exhibits significance and impact*—finding a balance between different leadership roles is important.

**Administrative leadership** resembles the traditional, bureaucratic, and hierarchical type of leadership (Uhl-Bien et al., 2007). It includes practices such as building vision, implementing strategy, and assigning work responsibilities (Hazy & Uhl-Bien, 2013). While these are often seen as strategies for building stable organizations, complexity leadership theory recognizes their importance for creating managed chaos (Nag, Corley, & Gioia, 2007; Uhl-Bien & Marion, 2009). After all, the goal is not to spin out of control, but to stimulate innovation and creativity in a way that is in line with the mission of the organization (Dess & Picken, 2000). More recently, Uhl-Bien and Arena (2018) have argued that administrative leadership should be relabeled as operational leadership, which focuses on how formal leaders enable the production of results through selection, execution, and efficiency.

**Enabling leadership** operates between administrative and adaptive leadership and it draws attention to the ways in which leaders can structure conditions that are optimal for problem-solving, adaptability, and new learning (Uhl-Bien and Marion, 2009; Uhl-Bien et al., 2007). It involves building an environment where diversity is appreciated and work groups are structured to enable interaction and collaboration. Enabling leaders are individuals who

adopt behaviors for enhancing interactive and adaptive dynamics (Uhl-Bien & Arena, 2018). They can act as brokers who bring individuals, ideas, and resources together and support exchange of information (Arena, Cross, Sims, & Uhl-Bien, 2017; Uhl-Bien & Arena, 2018). They also monitor the organization to better understand the different forces influencing the emerging adaptive dynamics.

Adaptive leadership is a complex dynamic rather than a role assigned to a person. It is an interactive type of leadership and it underlies emergent change activities. Ultimately, all heterogeneous knowledge-producing organizations should strive for adaptive dynamics and adaptive leadership. As the authors noted (Uhl-Bien et al., 2007), "adaptive change is produced by the clash of existing but (seemingly) incompatible ideas, knowledge, and technologies; it takes the form of new knowledge and creative ideas, learning, or adaptation" (p. 307). Later Uhl-Bien and Arena (2018) suggested that perhaps a better label for adaptive leadership was entrepreneurial leadership, which emphasizes the creation of new knowledge, skills, products, and processes in order to sustain the organization's success.

**Table 1. Leadership Skills and Competencies**

| Administrative Leadership | Enabling Leadership | Adaptive Leadership |
|---|---|---|
| Vision, strategy, and distribution of work tasks. | Brokering people, knowledge, and resources. | Promotion of a complex dynamic for creativity. |
| Skills and Competencies | | |
| Goal setting in a changing context (Entin & Serfaty, 1999)<br><br>Understanding differences in knowledge production across disciplines (Cilliers, 2013)<br><br>Openness to rearranging collaborative arrangements (Balsiger, 2004). | Communication, dialogue, and learning (Eigenbrode et al., 2007; Suldovsky et al., 2018)<br><br>Translation of knowledge across disciplines (Colditz, Wolin, & Gehlert, 2012). | Interpersonal conflict and change management (Lotrecchiano & Misra, 2018). |

Table 1 summarizes the three different leadership roles and provides a list of skills and competencies needed in each role. Complexity leadership theory suggests that by mobilizing enabling leadership, it is possible to find an optimal balance between administrative and adaptive forces. While administrative, enabling, and adaptive leadership roles are distinct, they are all simultaneously present, entangled, and interdependent when leaders seek to facilitate innovation (Kontopoulos, 1993; Uhl-Bien et al., 2007).

### *Connecting Activities*

Complexity leadership theory highlights the importance of connecting activities that can link ideas, information, people, resources, and technology in ways that scale novelty and

innovation (Uhl-Bien & Arena, 2018). Connecting activities are typically associated with enabling leadership. These activities may include knowledge brokering, joint training opportunities, and shared decision-making. Connecting activities are critical in the facilitation of adaptability and change in knowledge-intensive organizations (Arena et al., 2017; Taylor & Helfat, 2009; Uhl-Bien & Arena, 2018).

Indeed, knowledge brokering and bridging have been shown to foster learning and innovation in different professional contexts, for instance in healthcare (Lomas, 2007; Ward et al., 2009; Waring et al., 2013). While boundary spanning in collaborative knowledge work is known to be important, it has also been shown to be difficult to accomplish (Bechky, 2003; Haas, 2006; Huising, 2014; Kellogg, 2014; Majchrzak, More, & Faraj, 2012). In transdisciplinary contexts, a significant challenge is that the number of different boundaries is relatively high as collaborators come from, for example, academia, industry, and policy sectors. Furthermore, no matter which sector they come from, individuals have varying capabilities to facilitate boundary-crossing (Lotrecchiano, 2010; Lotrecchiano, 2014; Uhl-Bien et al., 2007).

In relation to these challenges, Uhl-Bien and Arena (2018) have noted that in complex adaptive systems connections will co-occur with conflicts. Conflicts are inevitable, but they can be productive if leaders simultaneously help individuals connect across differences and link up around adaptive responses (Arena et al., 2017). Both adaptive and enabling leadership play a role in how conflicts are managed. According to Lotrecchiano (2010), adaptive leadership strives to develop collaborators' conflicting perspectives into resolute outcomes. Enabling leadership, in turn, fosters interactions and interdependency and in this way supports the interactive and adaptive dynamics of complex systems.

## Methodology

The findings presented in this chapter are based on a longitudinal qualitative research project on a new transdisciplinary research center in the field of medicine. The center was located in a research university in the United States. It was formed through a partnership between the university's School of Medicine and a non-profit foundation that wanted to fund research directed at solving and reducing premature birth. Senior scholars from the School of Medicine—who later became the center's leadership team—wrote a research proposal to form a transdisciplinary research center focusing on premature birth.

The center's mission was to create new knowledge about premature birth through a transdisciplinary team science approach. The goal was to study and understand what leads to premature birth and ultimately translate this research into clinical interventions and policy changes. The organizational setup included four transdisciplinary research teams and a leadership team, which all contributed to the center's research activities. Each of the research teams had a methodological focus based on the team leader's previous research, but the participants of the transdisciplinary teams came from different disciplines. The four research teams focused on 1) understanding the role of the placenta in premature birth, 2) identifying temporal and geographical premature birth patterns, 3) finding biomarkers associated with premature birth related diseases, and 4) uncovering the role of microbial communities in cases of premature birth (see Mäkinen, 2018b; Mäkinen, 2019).

In addition to the meeting data, the five leaders and the administrator were interviewed at two different time points: when the center was formed and two years after. On both rounds, interviews were conducted based on a semi-structured interview protocol. While each interviewee was asked the same general questions, there was flexibility in how the varied issues they brought up were discussed in more detail. In practice, the interviewer asked different kinds of follow-up questions depending on how the informants responded to the planned questions (Corbin & Strauss, 2015).

The interview protocol for the first round of interviews focused on how the transdisciplinary research center was planned and formed. For example, the protocol included the following questions:

- What is your role in the premature birth center? How do you envision enacting this role in the center?
- What led you to current research on premature birth?
- What the teams' and their members' roles are? What are they expected to do?
- Are there things researchers seem to agree on? What do they disagree on?
- Can you describe some concrete ways in which the research will get translated into medical practice?

The interview protocol for the second round of interviews was concerned with how the center had evolved during the first two years, what kind of scientific progress had been made, what transdisciplinary science looked like in practice, and what challenges the leaders had experienced since the formation of the center. The interview protocol included questions such as:

- How have you experienced the past couple of years that you have been part of the center?
- How would you describe your current tasks and responsibilities in the center?
- How have your responsibilities changed during the past two years?
- How has the center changed during the past couple of years?
- How and where do you interact with members of the center?
- How have you experienced the regularly organized meetings?

A team of social scientists, which the author was part of, collected data on the center for almost three years since its formation. The team observed and recorded all of the meetings the center organized during this time. These meetings related to the center's varied research activities (e.g., work of the four research teams, center leadership team, and data collection efforts). A detailed description of the longitudinal data collection effort on the new transdisciplinary research center can be found in the author's article "Complexity Leadership Theory and the Leaders of Transdisciplinary Science" (Mäkinen 2018a). In what follows, I briefly describe the four transdisciplinary teams and then explain how data on the center's leadership team was collected and analyzed.

Data collection on the leadership meetings started in August 2011 and continued until November 2014. During this time, 128 leadership meetings, each lasting an hour, were observed. In the meetings, the leaders were gathered around an oval-shaped table in a seminar room at the School of Medicine. When observing the meetings, the author sat around the same table taking notes, but without participating in the conversations. The author used her

laptop to jot down and write up observations from the leaders' meeting interactions and conversations (Emerson, Fretz, & Shaw, 1995). In addition to note taking, there was permission to record the meeting discussions. These recordings were extremely helpful during the analytical stage as they allowed for double-checking that the content of discussions was understood correctly.

### *Transdisciplinary Research Teams*

The center had four transdisciplinary research teams: placenta team, premature birth pattern team, bioinformatics team, and microbiome team. The placenta team studied the role of placental cells in premature birth and focused on cases of placental failure. The team leader was a geneticist and his main collaborators came from the fields of genetics, OB-GYN, and pathology. Funding for the project was cut after the first year and the reasons for this outcome are analyzed elsewhere (Mäkinen, 2019). The premature birth pattern team identified geographical and temporal premature birth trends in the United States birth record dataset by using cluster analysis approaches. The team was led by a computer scientist and the team members included statisticians, epidemiologists, and clinicians and medical researchers from OB-GYN, neonatology, and pediatrics. The bioinformatics team studied which biological markers were associated with pregnancy related diseases. The team was led by a bioinformatician and most of the project's analytical work was done by bioinformaticians. However, there were also clinicians and medical researchers from OB-GYN and pediatrics who regularly attended meetings and contributed to the project. Finally, the microbiome team explored how changes in the mothers' microbial communities over the course of pregnancy contributed to premature birth (see Mäkinen, 2018b). The team was led by a microbiologist and its members included scientists from microbiology, immunology, and epidemiology. The center's leadership team consisted of five senior academics (all male) and one administrator (female). The academics represented different medical and scientific fields. They were tenured and established scholars in neonatology, pediatrics, OB-GYN, and epidemiology.

Because the transdisciplinary research center did not have its own building, meetings organized regularly for each of the previously described transdisciplinary research teams became an important strategy for supporting collaboration across disciplines (see Mäkinen et al., 2019). The meetings were opportunities for interaction as well as contexts for influencing how researchers should behave as members of the new transdisciplinary research organization.

The leaders had certain objectives for jumpstarting transdisciplinary collaboration in the center. First, it was essential to create a context for transdisciplinary conversations that went beyond the established lines of research that had dominated premature birth investigation for decades. Second, the shared team meetings were seen as the most likely context in which transdisciplinary interactions would take place. As the leaders participated in the team meetings, they allowed the leaders to monitor how transdisciplinary collaboration was progressing and use different leadership roles and practices to promote the creation of adaptive dynamics.

In an effort to exchange ideas and plan the center's activities, the leaders organized weekly meetings also for their own group. In these meetings, the leaders discussed issues relating to the management of the center. In their leader roles, they were responsible for a number

of things, such as, making sure scientific progress was made, identifying and attracting new talents into the teams, fundraising, preparing annual progress reports, and determining annual research budgets.

### *Analytical Approach to Meeting and Interview Data*

The analysis of the previously described meeting and interview data was motivated by the theoretical and empirical observation that leadership plays an important role in knowledge creation processes (Bryant, 2003; Lakshman, 2007; Politis, 2002; Srivastava et al., 2006). The author developed analytical codes that aligned with complexity leadership framework for uncovering how the leaders of transdisciplinary science mobilized and managed adaptive dynamics.

The analysis of ethnographic field notes from leadership meetings and interviews with the leaders consisted of two stages that can be characterized as initial and focused coding (Lofland & Lofland, 1995). During the initial coding stage, the author went through the 128 leadership meetings in chronological order and searched for evidence for different kind of leadership practices aimed at promoting transdisciplinary collaboration. These initial codes were defined, for example, as leadership practices aimed at developing a shared understanding of the problem of premature birth, engaging members in transdisciplinary conversations, and encouraging passive researchers to participate in research collaborations.

Before moving to the stage of focused coding, the author reviewed literature on leadership in knowledge-intensive organizations and used this prior research to make sense of the initial codes. This analytical stage required a modified grounded theory approach of comparison and contrast, where the initial codes were compared against the complexity leadership theory framework (Strauss & Corbin, 1990). Through an iterative process of reading literature and going through the initial codes, the author became convinced that the complexity leadership theory provided a useful framework for structuring the analytical coding of meeting observations even further. The leadership roles—administrative, enabling, and adaptive—and their related practices thus provided a set of focused codes for winnowing out less useful initial codes and focusing in on a selected number of themes (Lofland & Lofland, 1995; Uhl-Bien et al., 2007). This analytical process involved the identification of the three leadership roles and then connecting them with leadership practices present in the data (e.g., modelling transdisciplinary behavior, translation, brokering) (Uhl-Bien et al., 2007; Uhl-Bien & Arena, 2018).

Next, I present the empirical findings. I draw on meeting observations and quotes from interviews with members of the leadership team. When we began data collection, leaders were assigned identity numbers, which can be seen after each quote (e.g., ID-29).

## Creating Adaptive Dynamics

When creating a context for transdisciplinary collaboration, the leaders emphasized the need to generate innovative ideas about premature birth that were different from existing lines of research. While the leaders thought it was important to have premature birth experts in the center, they also wanted to make sure that new research paths were emerging. Researchers who had no experience with premature birth, but were included based on their analytical skills, were particularly important for achieving this goal. They could develop

unexplored hypotheses about the health problem. They would help in making sure that the transdisciplinary center created new and innovative discoveries rather than produced traditional research outcomes due to the pressure to produce (Uhl-Bien & Arena, 2018).

Adaptive dynamics emerge from a given interactive context characterized by complex social dynamics and patterns of behavior that have the power to generate innovative outcomes (Uhl-Bien et al., 2007). In the new transdisciplinary research center, the interactive context can be understood as the previously described shared weekly meetings, where members of the center came together to discuss research projects. In these meetings, researchers interacted, exchanged knowledge, and sought to produce transformative outcomes relating to premature birth.

### Shared Meetings as a Context for Adaptive Dynamics

Immediately after the center was launched, premature birth experts, who had spent their careers researching and taking care of pregnant women and premature babies, dominated the project meeting conversations. The threat of falling back on creating knowledge through disciplinary approaches was real. One leader said, "It's easier to fall back into a traditional mold and do studies that look a lot like all the studies we've done before in our careers, and so it gives us the semblance of the perception of progress, of success because we're publishing" [ID-29]. Connected to this, the leaders felt the meeting conversations were focused on what was already known about the health problem:

> They understand the problem according to the current paradigms. We don't know whether—well, the current paradigms have not been yielding with respect to solving the problem, right? We are missing something. That's why having a disposition that's focused on transdisciplinary discovery is so important. We want people to be open to new paradigms that would actually completely change the way you think about pre-term birth…It's changing the paradigm that's really important in research to solving these kinds of problems. Until you change the paradigm and know the new rules and new operations, you can't solve the problem; you just spin within the existing paradigm. [ID-27]

For transdisciplinary discovery to be successful, the leader thought it was important to separate the center's work from the current paradigms. To resist the influence of established lines of research, the leader emphasized that the center needed researchers who were "open to new paradigms." In fact, the leaders hoped that researchers would be able to internalize foreign research approaches to the extent that they would become unrecognizable to their home disciplines:

> We want people to think beyond where they are routinely thinking. If [name of an epidemiologist] has never dealt with a biological question in the signaling pathway, we would want him to do that more often, ultimately. Same for [name of a pediatrician]. If I'm not used to dealing with the way they think, then I want to do that—I do enough of that, actually. I'm learning about their fields. Pretty soon, if you met me for the first time, you would think I might be an epidemiologist or something, but I'm not. That's sort of where we are headed is that I would be able to have multiple cloaks, and so would they,

> have multiple cloaks. What we are hoping is that the students who are in these environments will naturally wear multiple cloaks. [ID-27]

This leader used himself as an example. He said he was not initially familiar with epidemiology, but increasingly, due to his interactions and collaborations with an epidemiologist, an outsider would have a difficult time identifying his disciplinary background. The leaders wanted everyone in the center to experience this transformation and to become hybrid researchers able to "wear multiple cloaks."

However, in order to initiate the process where existing expertise was broken down, rearranged, and recombined to generate something different, the meeting participants had to begin to interact. One leader said that the challenge they were facing was how to connect different researchers' mental frameworks:

> It is how you look at a problem. I think that what we are dealing with are different mental frameworks. The difficulty is how to appreciate what another person's mental framework would look like and how to get it to relate to your mental framework. [ID-8]

This cognitive incommensurability can prevent collaboration across knowledge boundaries (Cummings & Kiesler, 2005; Dougherty, 1992; Lamont, 2009; Murray, 2010). While in the context of the transdisciplinary research center there were multiple knowledge boundaries that needed to be crossed, the most challenging boundary was the one between premature birth experts and researchers with no prior experience with the health condition:

> The science gets deep for them [practitioners] pretty fast. They probably understand some of it but not all of it, and maybe not enough to really react to what people are saying, and the reverse is certainly true. We have basic scientists in the room who really know very little about pregnancy and premature birth. [ID-23]

When planning the transdisciplinary research effort, the leaders emphasized the importance of creating a new paradigm for premature birth research, which required learning from others and valuing their research approaches. These kinds of adaptive goals called for enabling leadership practices, which could promote interactions, interdependency, and adaptive tension (Uhl-Bien et al., 2007).

## Enabling Leadership Practices

Complexity leadership theorists argue that enabling leadership practices are necessary for creating, protecting, and maintaining a space for adaptive dynamics (Uhl-Bien & Arena, 2018). In order to create an environment where physicians, medical researchers, and scientists from different backgrounds could engage in learning and collaboration, the leaders of transdisciplinary science wanted to develop strategies for easing the crossing of knowledge boundaries. The leaders used modelling of transdisciplinary behavior and knowledge translation and brokering as their main enabling leadership practices.

### *Modelling Transdisciplinary Behavior*

The leaders promoted transdisciplinary learning and collaboration by modelling transdisciplinary behavior. They hoped that this enabling leadership practice would build researchers'

confidence towards independently taking part in transdisciplinary interactions. The shared meetings were the best opportunity to influence the behavior of everyone involved with the center. The leaders believed that demonstrating how to interact in a transdisciplinary environment was important for those who came from a science background.

> Traditionally, in medical science and sciences…the expression is that the more you can be expert at some tiny little field, the more likely you are to be very successful. Also, I think that the more you can present stuff that people can't understand, the more points you seem to get. If you can do a terrific presentation so that people know that you know what you're talking about, but they don't understand half of what you're saying, then that really builds your thing. [ID-8]

In a transdisciplinary environment, scientists had to demonstrate their expertise differently from the previous interviewee's description of typical seminar or conference behavior. The leaders were in a good position to demonstrate openness to new areas of knowledge to the other members of the organization. They were all established and respected scholars in their fields, so crossing disciplinary boundaries was not as risky for them as it was for junior researchers. For example, one leader was particularly effective in demonstrating to researchers how to interact across disciplinary boundaries. He acted as a sort of rebellious academic and thought out loud ideas that many perceived as nontraditional.

> I'm trying to push the envelope, so by example saying look, I'm willing to say stuff that maybe is outrageous and maybe it can stimulate something. Other people may be more timid about saying things that they feel might make them look non-expert or look foolish or something like that. Part of it, maybe they are not trained to do that, to make those jumps. [ID-8]

By being active in the meeting settings and expressing untraditional ideas, the leader hoped he could support intellectual risk taking in others. Risk taking, experimentation, flexibility, and play are crucial activities in complex adaptive systems and they can be promoted through enabling leadership (March, 1991; Uhl-Bien & Arena, 2018).

Leaders noted that even after their efforts to model transdisciplinary behavior, the senior researchers engaged in transdisciplinary discussion more often than the junior researchers did. Senior researchers seemed to be more at ease in transdisciplinary meetings. Of course, from the perspective of academic careers, the tenured senior scholars had less to lose.

> I think it is the more senior people who talk comfortably to each other, but it is sort of like demonstrating. It is sort of like showing—it is like kids watching their parents. The kids are modeling. If the scientists are modeling their interactions, in a way, then I think the students learn that that's the way it should be done. That's where you are going to get productivity. It's okay, actually, to ask these questions. 'Look at my mentor getting quizzed by [name of a senior scholar] and [name of a senior scholar]', you know? Or, 'Look at my mentor asking a question back to them which is getting them to say something that we don't really think about.' Once they get used to that, then it will be easier for the next generation to do these things, I think. It is modeling. [ID-27]

Although this modelling did not engage everyone in transdisciplinary conversation, this leader was not concerned. He perceived it as seniors modelling transdisciplinary interactions to juniors, like "kids watching their parents." Over time, the junior scholars would learn to participate in transdisciplinary thinking, ask questions, and share their expertise.

### Knowledge Translation and Brokering

Over the course of several months, the leaders came to realize that modelling transdisciplinary behavior was not enough for initiating learning and collaboration within the center. One leader said they had to continue to guide and manipulate collaborative interactions: "Transdisciplinary discussion has not evolved spontaneously. A little bit, but I think it really still requires a lot of manipulation or guidance" [ID-8]. Therefore, the leaders began to rely on another enabling leadership practice: knowledge translation and brokering. Arena and Uhl-Bien (2016) have pointed out that enabling leaders can establish adaptive space by brokering and bringing individuals together. In the transdisciplinary research organization, the shared meetings brought members of the center together physically, but knowledge translation and brokering were needed to connect actors intellectually. The leaders practiced these connecting activities both in and outside of meetings.

One-on-one interactions between a leader and a member of the transdisciplinary research community were important when the center was formed and nobody knew each other, or when new researchers joined the effort. These interactions allowed the leaders to get to know the specific researchers and get a sense of what their expertise was like. Consequently, they could make plans for how to integrate a researcher with particular expertise to ongoing research projects. Once the leader had an understanding of what the researcher was able to do, he could translate this expertise to the other members of the center. One leader explained how he approached a researcher who had recently joined the center:

> Like, I asked [name of a scientist], I said, 'Tell me what you are doing in more detail, like a paragraph,' so he sent it to me. I have that; no one else has that yet. I had a sense of what he was doing from what he told me, and I said, 'Well, do you have papers that you have published?' 'No.' I said, 'Well, then, tell me yourself, in your own words, in about a paragraph what you do.' I will take that and I will then massage that in a way that begins to make sense to other people. I will translate what he is doing in-to their worlds. [ID-27]

This example demonstrates the work the leaders did as translators. First, the leader familiarized himself with the work of the researcher, and then introduced his work to others whose projects might benefit from the new researcher's input. The leader invited the researcher to attend project meetings, supported his presence in the meeting, and suggested ways in which he could contribute.

The translation work continued in every interaction the leader had with members of the center. He wanted to understand how the researchers approached research problems and then tried to guide them to think in new ways. This practice relates to "injecting tension into the system," which is one strategy for opening up the adaptive space (Uhl-Bien & Arena, 2018, p. 11). The leader had to do this delicately so as not to create too much tension and conflict between differing perspectives.

> When I interact with people, I want to know what they are thinking about. I will ask them questions like, 'How do you think that relates to such-and-such?' and then let them think out loud about it. If they are comfortable, they will think about it. They may not necessarily say, 'Well, I have got a bit of an idea.' Instead, I will say, 'Well, did you ever think about this?' and then they will say, 'Hmm, interesting' and it goes from there. [ID-27]

While in the shared meetings, researchers' different ways of doing research and thinking about premature birth sometimes clashed, the one-on-one conversations between a leader and a researcher had a different tone. The leader did not challenge the researcher's work, but instead expressed interest in it and suggested new ways of approaching it. In a similar manner to how the leaders modelled transdisciplinary behavior in shared meetings, this leader demonstrated how researchers from different backgrounds could interact without too much confrontation.

In addition to this behind the scenes translation work, the leaders acted as knowledge brokers. Uhl-Bien and Arena (2018, p. 12) have noted that "connecting involves linking up agents (i.e., ideas, information, people, resources, technology) in ways that scale novelty and innovation into beneficial new order in the operational system." In line with this, the leaders developed brokering tactics to connect the different individuals and their perspectives.

The challenge was that, while in private conversations the leaders could motivate researchers to talk about their work, in the shared meetings many researchers became silent. This was because in the heterogeneous project meetings the conversation could go in multiple directions and include topics a researcher was not familiar with. As this leader described: "You just talk to people about the things that they are good at doing, then they will talk about them easily. If you talk about things they don't do on a regular basis, they don't talk" [ID-27]. As such, the leaders sought to first activate individuals who were more silent in order to make sure that different perspectives were heard. This was easier when the leaders were leading the meeting. This leader described his own role:

> I saw my role as to try to at least foster transdisciplinary discussion around whatever we were doing. I tried, and this has evolved over time, to provoke transdisciplinary discussion either by calling on people or asking questions or to try to get people involved to get the transdisciplinary perspective. [ID-8]

When heading the meeting, the leader relied on tactics such as calling on people and asking them questions. In this way, the meeting conversations included more perspectives. The next step was to connect different individuals or groups at a concrete level.

> I see that as an important role, trying to promote transdisciplinary thought and trying to get people linked up. Often I will try to suggest that maybe two projects that are doing things that are different, but could combine them, would actually work together or at least to think something out. That's just starting to emerge. I have been trying to do that for a long time, but I think it's finally starting to come together…I think that building a transdisciplinary team takes a long time. [ID-8]

The leader paid attention to everyone present in the project meetings he led. He made sure participants were active and made connections with others in the room.

The statement that transdisciplinary thought was "just starting to emerge"—made two years after the formation of the center—highlights how much time and effort the leaders had to put into mobilizing new transdisciplinary research collaborations. While the discussed enabling leadership practices were critical for promoting transdisciplinary collaboration, their benefits did not materialize right away.

## Administrative Leadership and the <mark>Management of Transdisciplinary Science</mark>

The described enabling leadership practices were crucial for jumpstarting learning and collaboration, but demanded that the leaders take a central role in the management of transdisciplinary science. When the leaders brokered researchers and projects, they identified promising projects, decided on how research resources were used, and provided roles for collaborators. In complexity leadership theory, these practices are associated with administrative leadership (Uhl-Bien et al., 2007; Uhl-Bien & Arena, 2018). This section discusses the delicate relationship between different leadership roles and suggests that an imbalance in this relationship can prevent some actors from contributing to research collaborations and can jeopardize the creation of adaptive dynamics.

Enabling leadership practices began to shift towards administrative leadership, when more and more researchers became interested in the transdisciplinary research organization. As research funds from the NIH were increasingly difficult to get, medical researchers and scientists, beyond those initially included in the effort, began to show interest in the transdisciplinary study of premature birth. The center had a biweekly research seminar, where researchers outside the center could come pitch their research ideas to the leadership team. One leader explained that the increased interest in the center's premature birth grant forced them to deal with an overabundance of promising research ideas:

> Having funding from a foundation and having restricted funds on the NIH side actually makes it a little bit more likely that investigators that were otherwise perfectly fine and happy, because they had plenty of money, are now headed in this direction to see if they can find money to do work. That's an irony of the circumstance, which actually provides incentive to people to congregate and begin to work on this [transdisciplinary study of premature birth]... The trouble is, we don't have enough money to incent everybody. They can come and present a great idea, and then the next thing they want is money, and we don't have enough. [ID-27]

The leader was pleased that researchers from different fields were interested in the effort and proposed ideas for how to study the syndrome. However, there was not enough money to support every project, no matter how promising the research ideas were. Ultimately, the leaders had to decide what was worth funding, which was a great responsibility in a situation where nobody knew what was causing premature birth.

Furthermore, while premature birth seemed like a narrow research problem, there were multiple different research paths that could have been taken to create new knowledge on the topic. The leaders had to make sure there was a sense of direction for the research effort; otherwise it would be challenging to make progress. Here is how one leader explained it:

> The biggest problem is that every [research] avenue looks exciting. It looks 'oh my God, it's so interesting.' The leadership group, our job is to try and be sure that we keep the train going forward because otherwise we are going to be going like this [gestures a circle]. That's difficult because everything's exciting. Everything looks great, but you have to be able to keep focus and try to bring it all together. [ID-7]

One strategy for keeping "the train going forward," as the leader said, was the initial decision to focus on four transdisciplinary research projects. The leaders selected these projects already before the center was formed. As these projects led to discoveries, new research avenues began to emerge. In many ways, this development was something positive. Multiple interesting research avenues could be signs of intellectual chaos that could lead to more creativity and development (Nonaka & Yamanouchi, 1989). Again, the leaders had to decide which research ideas were worth the limited resources. One leader confessed that they had made some mistakes along the way:

> We have to think about, practically speaking, what are the synergies that we might fund? What are the people that are likely to actually work well together and make choices that reflect that? So far we are doing okay, but we have made some mistakes, too…. It's self-serving their goals in trying to understand [referring to a project on infection and premature birth], which is what [a scientist] is interested in. It's just not engaging enough for a lot of the people, so that's money that we spent that probably is going to go nowhere. Now, it might ultimately get her a grant and it might get her a few papers, but I am not sure it's going to contribute much to premature birth, to be blunt. [ID-27]

The leaders did not want to pick projects only on the basis of what was a promising idea. They wanted to identify researchers who were able to work with others and create collaborative synergies across the center and its projects. They wanted researchers who were "open to new paradigms." While the leader said they were "doing okay" in their attempt to support the best possible projects, they had also made some mistakes. One project they had decided to fund was helping the individual scholar and her career, but not necessarily the transdisciplinary study of premature birth.

When a complex adaptive system relies on administrative leadership too heavily, the relationship between different leadership functions becomes unbalanced, which can threaten the creation of adaptive dynamics. The leadership team was in a position to guide knowledge creation toward directions that they selected based on their knowledge of premature birth research, new discoveries from ongoing projects, and synergies among members of the center. While this behavior may have guaranteed the production of research outcomes, the adaptive dynamics suffered from a lack bottom-up processes, such as experimentation (Uhl-Bien & Arena, 2018).

## Discussion: Establishing Entanglement and Interdependency in a New Transdisciplinary Environment

Complexity leadership theory provides a framework for analyzing how leaders of transdisciplinary science mobilize and manage collaboration across disciplinary boundaries. The purpose of this chapter was to shed light on the role of leaders in a newly formed transdis-

ciplinary research organization. Next, I reflect on the challenges for establishing entanglement of leadership functions and interdependency among organizational members in a new research center. I discuss how the lack of entanglement and interdependency can explain why the leaders became the focal points of knowledge creation and how such a development can be prevented.

Complexity leadership theory emphasizes that while administrative, enabling, and adaptive leadership roles are distinct forms of leadership, in effectively functioning organizations they need to work together (Hazy & Uhl-Bien, 2013; Uhl-Bien & Marion, 2009; Uhl-Bien et al., 2007). Ideally, these different forms of leadership exist in a dynamic relationship, entangled with one another. In this way, they support the creation of adaptive dynamics in complex systems. However, in this new transdisciplinary research organization, it seemed that the different leadership functions were not sufficiently entangled. Instead, they formed a kind of leadership toolbox from where the leaders selected a function and related leadership practices that suited a given situation.

In addition to weak entanglement of the different leadership functions, the leaders had a difficult time with fostering interdependency among the members of the transdisciplinary research center. Uhl-Bien et al. (2007, p. 310) noted, "While interaction permits the movement and dynamic interplay of information, interdependency creates pressure to act on information." This means that simply increasing information flow in a complex adaptive system is not enough. Experts need to develop interdependency among themselves so that there is a real incentive to collaborate. The leaders of transdisciplinary science relied on practices that fostered the movement and interplay of different types of expertise, but in the new research organization, the researchers were not immediately dependent on each other. When collaborative relationships between people were not yet established, it was not clear where interdependencies could develop or where they were even necessary.

Weak entanglement of leadership functions and lack of interdependency among members of the organization challenges the creation of adaptive dynamics. The leaders were eager to support the creation of adaptive dynamics by relying on enabling leadership practices. They saw value in connecting activities, which are important for the facilitation of adaptability and change in complex adaptive systems (Arena et al., 2017; Taylor & Helfat, 2009; Uhl-Bien & Arena, 2018). Knowledge brokering and translation were particularly important, because most of the collaborators were not familiar with each other or the problem of premature birth.

Yet, quite quickly, the leaders faced a situation where there was a pressure to produce results. Transdisciplinary research organizations—especially when they are new and have not yet developed stable knowledge creation processes—can struggle with jumpstarting collaborations that can lead to innovative research outcomes. The risk tends to be that the pressure to produce products comes in the way of the need to innovate (Uhl-Bien & Arena, 2018). In order to ensure transdisciplinary research outcomes, the leaders began to rely on an administrative leadership role. These challenges—connecting members in the new center and ensuring that progress was made—and the leaders' responses to them made the leaders the focal point of transdisciplinary knowledge integration. When the leaders translated and brokered knowledge in line with enabling leadership, they became knowledgeable of all the expertise present in the center. They then used the gained knowledge to broker

expertise and people on transdisciplinary research projects. Finally, they had the opportunity to assess research ideas and decide which projects to support.

Leaders becoming the focal point of knowledge integration has consequences for a system's adaptive dynamics. According to Lotrecchiano (2010), successful transdisciplinary environments require knowledge feedback loops that run throughout the organization on multiple levels. If formal leaders act as the focal points of knowledge integration, the knowledge feedback loop is not likely to draw on the expertise of all organizational members in an optimal way. Similarly, in relation to facilitating adaptive processes, Uhl-Bien and Arena (2018) emphasize the importance of both top-down and bottom-up processes. Both are important, but they need to be integrated in a dynamic way.

It is important to remember, though, that the empirical context of the present study sheds light on the challenges of building adaptive dynamics in a new transdisciplinary center. Despite the tendency of the leaders to take charge of transdisciplinary knowledge creation in these early stages does not determine what the organization's future will be. While these findings increase our understanding of what goes on in recently established transdisciplinary environments, they do not presume a long-term outcome for the center. When organizational members gain collaboration experience, familiarity, and trust, transdisciplinary collaboration at all organizational levels is likely to become easier.

How to, then, mobilize transdisciplinary collaboration in a new center and avoid the described challenges? This chapter suggests that knowledge brokers capable of interacting at knowledge boundaries should be placed throughout the organization in strategic positions. These strategic positions might include individuals who lead teams, recruit researchers, and head meetings. A study on brokering activities in the area of patient safety by Waring et al. (2013) showed that those in more informal roles can be more effective at knowledge brokering, because they rely less on bureaucratic authority and more on professional and relational qualities. Recruiting individuals who are open to new knowledge and skillful at knowledge brokering is important in transdisciplinary research organizations. When the role of knowledge brokers is not based on bureaucratic authority, they are in a position to form connections across projects and to generate interdependency more easily than formal leaders.

## Conclusion

Transdisciplinary research organizations are complex adaptive systems in the sense that they bring together experts from varied backgrounds, promote interdependence among them, and form dynamic collectives with common goals (Cilliers, 1998; Lotrecchiano, 2010; Marion, 1999). This chapter examined what kind of leadership roles and practices leaders of transdisciplinary science rely on when seeking to promote adaptive dynamics. The analysis of empirical findings utilized complexity leadership theory, because it provided analytical tools for understanding the role of leaders in emergent collaborative contexts (Hazy & Uhl-Bien, 2013; Uhl-Bien & Marion, 2009; Uhl-Bien et al., 2007).

The chapter demonstrated that although academic leaders relied on different types of leadership practices, finding an optimal balance between administrative, enabling, and adaptive leadership was challenging. The leaders first drew on practices related to enabling leadership. Later on, they took on an administrative role, as there was an increasing pressure to

show progress. In this role, the leaders decided on promising research ideas, the use of resources, and project composition. As these practices relate to top-down leadership and decision-making, the leaders became the focal point of transdisciplinary knowledge integration. This, in turn, created an obstacle for the creation of shared adaptive dynamics throughout the research organization.

### Questions to Further the Discourse

- *Leadership throughout the transdisciplinary research process:* What is the role of leaders at different developmental stages in the transdisciplinary research process?
- *Sharing leadership throughout organization*: How to promote the sharing of leadership across organizational levels?
- *Leaders and followers in the creation of adaptive dynamics:* How do different organizational members take part in the creation of adaptive dynamics?

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