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How Do We Collaborate?

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Abstract

This chapter summarizes observations, insights, and ideas that arose during a series of discussions aimed at understanding how people collaborate. Three primary characteristics of collaboration emerged: its multidimensionality, sensitivity to context, and dynamism. They are discussed within a general conceptual framework, and historical and present-day examples are provided. First, collaborations of any size build upon and are scaffolded by a complex set of coordinates, constraints, rules, and behavioral regulations that distribute activities, authorities, and structure the social and material environment to support the collaboration. These choices, which make up the collaborative architecture, can be explicitly designed or evolve spontaneously during the collaboration. Second, collaborations need to adapt constantly to changing demands and circumstances across multiple timescales. Successful collaborative architectures tend to be highly task- and context-dependent, and mindful of the diversity of participants, local culture, and the extent of goal alignment and trust. Third, collaborations are dynamic processes; their design changes over time with limits imposed by environmental, material, and cultural structures. Collaborations should thus be viewed as complex adaptive systems that develop over time, contingent on the demands of changing circumstances and internal/external feedback—a perspective that resists reductionist analysis. Collaborations can be messy and unpredictable as well as incredibly resilient and persistent. Thus, the study of collaboration must be approached with humility and prudence.

Introduction

The question of how people collaborate invites us to think about the ways in which we organize the multiple, unfolding activities that occur within a collaboration as well as the implications of this organization on processes, participant experiences, and outcomes. This question has been the subject of study across several disciplines, including psychology (Wood and Gray 1991), political science (McDermott and Hatemi 2010), and organizational studies (Patel et al. 2012). Building on this literature, we take an interdisciplinary perspective

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that highlights key attributes and core components of collaboration. We propose a conceptual map of collaboration "in the wild," which we hope will be of practical use in building robust and resilient collaborations.

We assume a broad scope of possibilities and consider forms of collaboration, ranging from small-scale "one-shot" solutions to specific problems, to more analytically and theoretically interesting cases involving large-scale interpersonal engagements over time. We begin by laying out three main attributes of collaboration: its multidimensionality, sensitivity to context, and dynamism. Thereafter, we articulate four core components that underpin the "how" of collaboration: tasks, agents, architecture, and environment.

Attributes of Collaboration

Multidimensionality

Any collaboration has a *collaborative architecture*, a scaffold that coordinates, constrains, and directs the activities of the agents (see Chapter 14, this volume). Collaborative architectures can take a multitude of forms, from informal casual habits and routines to more explicit scripts, norms, rules, or protocols, and even material structures. The furnishing of a meeting room, for instance, can promote a particular activity or relationships between individuals who are collaborating on a project. A room where the chairs are arranged in a circle may signal equality of power, whereas a room set up with a table and chair for a leader facing chairs placed in rows may reinforce power differences (De Korte et al. 2011; Hua et al. 2011; Oseland et al. 2011).

Sensitivity to Context

Not all features of a collaboration and its underlying structures need to, or can, be formally designed; many, in fact most, emerge spontaneously during the collaboration and might never become subject of explicit negotiation. Yet, they often constrain and govern the collaborative activity in ways similar to explicitly designed rules. Maine lobster harvesters, for example, punish those who deviate from their collaborative agreement by cutting their lines. This form of sanctioning, as opposed to destruction of property or physical punishment, may have emerged in this specific context because it removes the incentive to fish in someone else's location at little to no cost to the enforcers (Acheson 1988).

At the core of the process of designing collaborative architectures sits the question of which features to define formally in advance, and which are allowed to emerge. Neither the choices made, nor the design itself, are likely to be optimal, not only because of the considerable number of potentially effective collaborative architectures but for two additional contextual reasons.

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First, contributors to a collaboration have various world models, traits, and attitudes. When collaborating agents are not aligned, they might find themselves with competing or inconsistent mental models and narratives, ambiguous categorizations of their environment, and uncertainty with respect to an understanding of the collaborative architecture in the given circumstances. In this case, the best that can be hoped for is that choices are consistent with the agents' subjective assessment of the form and likelihood of future events. Even if that were possible, as added information arrives, an optimal design would need to adapt continuously, and any sense of static optimality is therefore ephemeral.

Second, the foundation underneath a collaboration rarely remains fixed, in large part due to the collaboration itself. Especially in the context of long-term or perpetual collaborations (e.g., building a community or managing a common), the problem or opportunity that led to the collaboration may change over time or even disappear. In fact, the objective of the collaboration can be the collaboration itself, as in a neighborhood group that seeks to foster a sense of community through various activities. Thus, important as they may be, initial design choices are just the beginning—the starting point or takeoff of an adaptive collaborative process.

Dynamism

As collaborations unfold, people sense, act, and adapt to changes in the collaborative environment such as reconsidering initial design choices, whereby new collaborative features and properties can emerge. Feedback loops that emerge from the environment as well as the collaboration itself will frequently be the proximate causes of both individual and architectural adaptations (see Chapters 5 and 12, this volume). Collaborative feedback involves information about the collaboration itself: Is trust being built between people? Are roles equal? Do some people appear to be free riding? Is the collaboration meeting its stated goals? Utilizing this feedback, participants may decide to change some features of the collaborative architecture. For example, participants in an academic collaboration may discover frequent violations of a formal rule that precludes the use of specific tools, such as Google Docs. To encourage the overarching norm of rule-following, they might choose to relax specific rules. Alternatively, they could enforce the rule more vigorously, accepting that this could negatively impact how people feel about the collaboration and its fairness (for further discussion, see Chapter 11, this volume).

Environmental feedback involves information about the success of a collaboration and whether and how the collaboration is producing changes in the environment. For a collaborative agile software development project, environmental feedback might involve information on a series of benchmarks about how the code performs and whether end-users accept the results. For a local community, environmental feedback could include both objective data (e.g.,

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the number of attendees at an annual festival) as well as less tangible observations (e.g., the strength and density of social ties). Environmental feedback can include not only how well the collaboration performs with respect to its stated goals—whether children are healthier, water is cleaner, periods of famine are less severe, our new websites work—but also in terms of its effects on the external world; that is, the natural and built environment as well as the culture within which the collaboration occurs.

In response to collaborative or environmental feedback, adaptations can be path dependent, driven by previous feedback, adaptations, and outcomes. In some collaborations, as members develop greater trust in the ability of the collaboration to adapt, coordinate, and achieve progress toward a set of goals, rules may relax and the collaborative structure may become less hierarchical. To illustrate, consider the dynamics in a school classroom. Initially, teachers might favor a more formal mode of interaction with their students to establish their authority. However, as a teacher and students build relations, rules may be relaxed and more informal forms of interaction might become the norm (McFarland 2001; Walters and Frei 2007). In other types of collaborations, members may attempt to increase efficiency by adapting new goals or formalizing roles and responsibilities to a greater degree.

To summarize, based on the multidimensional, contextual, and dynamic nature of collaborations, we suggest that the question of "how people collaborate" is best answered with reference to the concept of *collaborative architectures*, which are neither given nor fixed; they are the product of innumerable acts of conscious design, actions, and spontaneous emergence. Collaborative architectures change over time in response (a) to adaptations by the agents acting within them, (b) due to the success or failure of the collaboration, and (c) due to changes in the world, including those produced by the collaboration itself (Chapter 5, this volume). This consideration allows us to investigate the architecture of a specific type of collaboration in terms of why it is successful or not, by systematically mapping out the properties of the architecture: Is it implicit or explicit? Is it flexible or rigid? Is it characterized by a flat or hierarchical organization? Is it voluntary or enforced?

Figure 17.1 illustrates how agents form groups that engage in collaborative activities or tasks. Collaborative architectures provide roles and rules that either emerge from the social interaction itself or are designed and superimposed on the interaction by the participants or third parties. In addition, agents and architectures are embedded in a physically and culturally shaped environment that also provides constraints on collaborative activity.

Collaborative Architectures

Any collaboration is constructed around a *collaborative architecture*, a scaffold that coordinates, constrains, and directs the activities of the agents (Chapters

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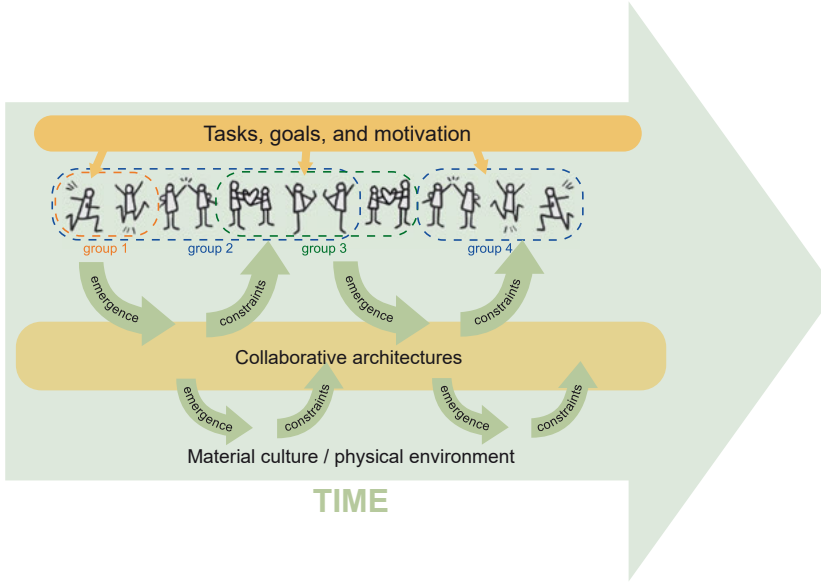

Figure 17.1 A multilevel and dynamic depiction of collaboration. Once a task or goal is established (group 1), motivation is cultivated (group 2) to engage agents and groups in the collaboration. The collaborative architectures that support action (group 3) are dynamically connected to feedback from the environment; emerging constraints lead to adaptations to ensure successful collaboration (group 4).

5 and 14, this volume). Collaborative architectures can take a multitude of forms, from casual habits and routines to more explicit scripts, norms, rules, or protocols, and even material structures. For example, organizing a settlement site so that the houses are placed in a circle or in rows may promote particular activities or relationships among the individuals who live there (Grøn 1991).

Building a collaborative architecture involves several design choices (ranging from goals, monitoring, and allocation) that will be determined by the goal set for the collaboration. A community managing a forest, for instance, will likely develop a method for monitoring the clearing of old and planting of new trees, as well as a process for settling claims of overharvesting and free riding (Ostrom 2015). Other choices concern the specifics of dividing, monitoring, allocation, and adjudications. For example, the scholarly community may rely on mutual monitoring of the quality and validity of research output, whereas harvesters might require the intervention of third parties (e.g., a land registry and a police force) to settle claims. Further, the formulation of a particular architecture needs to be sensitive to the intrinsic dynamic nature of the collaborative process so that it can tolerate changes throughout all of its processes, within reasonable bounds.

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Collaboration is a process that unfolds over time and is subject to continuous change. Although solving a specific task occurs on a different timescale than building a community, both are dynamic processes that require participants to monitor and adapt their behaviors and roles in response to feedback from the environment and the collaboration itself. Thus, participants monitor properties of the social interaction (e.g., is it fun, enjoyable, productive) as well as its external impact (e.g., has the goal been accomplished). As participants learn from one another and the environment, they may need to redefine goals, change the network structure, build stronger mechanisms of accountability or enforcement, or redesign roles. In this view, collaborative architectures are never static. They evolve in response to the dynamic processes that they regulate on multiple timescales, from the short term to the long term (Chapter 5, this volume). An example can be found in Rosenberg et al. (2022). In this experimental study, participants were randomly assigned to pairs and asked to perform a creative task collaboratively that involved moving tiles on a large touchscreen to build figures. Importantly, participants did not receive instructions about whether or how they should collaborate. This experimental setup allowed researchers to investigate how participants spontaneously organized themselves around a task. From the clustering of participants' tile moves, three different collaborative architectures could be identified among pairs of participants:

1. One pair member would end up making all tile moves (dominance).
2. One pair member would move around tiles to make a figure, then save it, and leave the floor to the partner, who would make another figure and save it (division of labor).
3. Some participants would take turns at every move to co-create figures.

In other words, participant pairs spontaneously arrived at quite different collaborative architectures to solve their coordination problems, and this had implications for their respective solutions (see also Bjørndahl et al. 2015).

When a collaborative architecture is well designed or contextually appropriate, it assists individuals in directing their activities toward a shared goal by providing a scaffold of rules and roles. In these cases, the group activity may take on *synergistic* properties (Fusaroli et al. 2014; Fusaroli and Tylén 2016; Riley et al. 2011). That is, the group's potential to act in the world exceeds the mere sum of its parts. In interpersonal synergies, the coordinative behaviors of individuals become "coupled" to form an emergent, supra-individual level of organization, a kind of *group agency* that is not reducible to the individual contributions. This allows the synergistic group to solve tasks or problems that cannot be solved by a collective of uncoordinated individuals (Bang et al. 2014). It is a form of collective intelligence that predicts group performance across various task and challenges (Riedl et al. 2021). Collaborative architectures, however, can also straitjacket collaborations. Norms or institutions that

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unduly constrain the dynamic process or goals of a collaboration can cause conflict and lead to failure.

Although collaborations unfold over time, we can characterize architectures by their *synchronic* properties. That is, although collaborations are dynamic, we can still identify their organizing and material features at any given moment in time. At the core of the process of designing collaborative architectures sits the question of which features need to be formally defined in advance and which will be allowed to emerge. Neither the choices made nor the design itself are likely to be optimal, not only because of the considerable number of potentially effective collaborative architectures but for two additional reasons.

First, any attempt to classify or make a taxonomy of collaborative architectures is hampered by the mind-blowingly large number of collaborative architectures of tremendous diversity: this encompasses everything from the architecture of a sitcom's writer's room (a loose collection of rules, norms, roles, seating arrangements, and social decision-making protocols) to the far more elaborate architecture that governs the decades-long collaboration among scientists at the CERN particle collider (Engeström et al. 2015; Fjeldstad et al. 2012; see podcast by Sijbrand de Jong[1]). Second, and as a result, collaborative architectures cannot be chosen from a list (Chapter 14, this volume). Consider, for example, Elinor Ostrom's research, which focused on the limited case of communities managing common pool resources. Even within this category, she uncovered an extraordinarily complex composite picture of emergent and designed collaborative architectures in different cultural settings, ranging from Balinese irrigation systems to grazing regulation in the Swiss Alps—architectures which were used, for example, to monitor, punish, and reward group members (Ostrom 2015).

The following thought experiment serves to make this complexity concrete. We considered the task of allocating offices among members of an organization, such as an academic department. Possible ideas ranged from an open collaborative process (e.g., an all-group meeting to allocate rooms in a consensual manner) to a process where people claim offices and potential conflicts are handled by those who want the same office. Alternatively, a bidding process could be considered. Other collaborative processes can be more structured: the group could design strategies for eliciting preferences and rank them or select a leader to make allocation decisions. Indeed, there are many solutions to a simple, one-shot problem.

To map out a few of the central dimensions that organize the landscape of collaborative architectures, we focused on three: (a) implicit versus explicit, (b) rigid versus flexible, and (c) flat versus hierarchical.

The first dimension reminds us that collaborations range from communities relying on implicit rules, procedures, and norms to explicit formal organizations (Enyedy and Stevens 2014). Features of collaborative architectures can

[1] https://esforum.de/forums/ESF32_Collaboration.html?opm=1_3

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be implicit or explicit. An architecture can structure the ongoing behavior of agents without ever being explicitly negotiated or agreed upon. Agents may not be fully aware that a structure exists in a space of alternative ways of organizing the collaboration. On the other end of the scale, explicitly codified architectures can exist with formal rules written down or otherwise explicitly known to all agents.

The second dimension, rigid versus flexible, is central to our framing of collaborations as adaptive systems. It defines whether rules that govern collaboration are loose or strict, flexible or inflexible. An architecture can have a very rigid specification of roles and procedures, or it can be very open and leave roles and procedures to change dynamically over time. Importantly, this dimension is independent from the implicit/explicit parameter. For instance, in open-source software development, rules are typically loose; this enables contributors worldwide to suggest improvements or new features and fosters innovation and adaptability. Conversely, in corporate joint ventures, collaboration is often governed by stricter rules to protect investments and intellectual property, with well-defined roles and procedures to streamline decision making and minimize conflicts. This flexibility or rigidity in rules plays a critical role regardless of the collaboration's explicit or implicit nature. For example, to encourage creativity and interdisciplinary integration, academic research collaborations often benefit from a looser set of rules, whereas emergency response teams might operate under a hybrid model that combines a clear command structure with the flexibility needed to adapt to the unpredictable nature of emergencies. Thus, whether the rules that govern collaboration are loose or strict significantly impacts the system's ability to adapt and evolve, making this an essential dimension in understanding collaborative systems.

The third dimension is the hierarchical structure of the collaboration, which is both prominent in the literature and affords a discussion of the role of structure and authority in collaboration. Interactions among collaborators can range from flat-open to hierarchically structured (Pisano and Verganti 2008). This feature plays a significant role in the ability of collaborations to leverage diversity and adapt to group size. Diversity offers both promise and potential peril. Some types of diversity (e.g., differences in skills, knowledge, information, and participation) are necessary for collaborations to be successful (Woolley et al. 2010) and for the whole to be more than its parts. Other types of diversity, or second-order diversity (e.g., goals, intentions, behaviors, and norms), can create frictions in dyadic and group interactions and collaborations. Anyone who has ever joined a pickup game of basketball (or any other team sports) will be aware of the potential for conflict that arises from disagreement about when a rule is violated. A hierarchy—in the pickup game example, a referee—might help prevent conflict among second-order diversities, but it might also reduce the flow of information and restrict feedback. With a referee, for example, the players will have fewer incentives to generate new rules that might be better adapted to their particular setting. In contrast, a flat structure will promote

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equality of voice but could lead to chaos. In the pickup game, if all players propose their version of when the rule is violated, it will be hard for them to agree and get on with the game. Different objectives and contexts of collaborations might follow certain features. For instance, when collaborations address high-stake issues (where the cost of failure is high), more explicit and strictly codified architectures might be necessary. A canonical example of this is the architecture that regulates traffic rules (Hawkins et al. 2019a). In the context of more explorative collaborative processes that relate to research or creative practices, loose structures might fare better.

Hierarchy may also play an important role in the design of collaborative architectures and how we understand their behavior. Simon (1962) makes a strong case for the importance of the notion of hierarchy in modeling complex systems, since many natural systems are "near composable," where the interactions within or between hierarchic components of the system can be separated, combined with the degree in which hierarchical systems facilitate descriptions of their structure as well as the flow of information between its components.

Core Components of Collaboration

Tasks, Goals, and Motivation

Individuals can be simultaneously involved in a variety of potentially overlapping collaborative tasks involving family, coworkers, members of a cultural group, or the broader community. It therefore seems that collaboration can be functionally defined by the nature of the task(s) that agents perform. For example, agents can collaborate to forecast, explain, understand, share, become, create, sustain, improve, design, manage, monitor, and play. Furthermore, the type of task that a collaboration might undertake can be categorized as a one-shot (e.g., solving problems, predicting, designing, and creating) or perpetual task (e.g., managing, sense making, and community building). Other collaborative activities might be episodic, such as in collaborations that take the form of play or the creation of art and beauty. Regardless of the task targeted by the collaboration, it will require some instigation or motivating cause: an external threat from the environment; a sudden opportunity for financial gain; a shared desire to build common rituals, existing traditions, or even an intrinsic urge to sustain positive social relations. These motivating causes can be *instantaneous* and *momentary*, such as when rising waters flood and wash over the banks of a river. They can also be *accumulating*, such as with rising levels of carbon in the atmosphere. Motivating causes can also come in combination, such as where a growing sense emerges in a community that their children need better educational opportunities because the children are unable to read a religious text.

Collaboration is often defined as a coordinated activity among a group of agents with similar goals (Chapter 1, this volume). Assuming that both agents

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individually and the collaboration itself are goal-directed entities begs the question of goal alignment: Do individuals need to align their individual goals to those of the group for the collaboration to succeed? How does the group goal integrate with the individual goals of each participant? Finally, goals in a collaboration can be explicitly defined or they can be implicit, in the sense that agents participating in the collaboration might not be consciously aware of, or not have, a clear common goal specified by the time they engage in a collaborative activity.

Understanding collaboration as a complex adaptive system, we suggest that within each collaboration, and across many levels of the collaborative architecture, individuals may be guided by more than one goal, and that these multiple goals can be expected to either align or conflict. However, since collaborations do occur and succeed under these common conditions of goal divergence and alignment, we suggest that fully aligned goals are not a critical prerequisite for collaboration. Once a collaborative architecture is established, it supplies the group with rules and roles, allowing the individual group member to recognize and fulfill their part in pursuit of their own goals and motivations, which might be similar or different from those of fellow group members.

Agents and Groups

The effectiveness of a collaboration is significantly influenced by the characteristics of the participating agents, along with the size and organizational structure of the groups they form within the collaborative framework. Central to the dynamics of collaboration is the diverse amalgamation of agents and groups, which may align or differ in their objectives. The accessibility of information, alongside the distribution of knowledge and capabilities, plays a pivotal role in shaping both individual and collective behaviors. This diversity, while a potential source of rich innovation and problem solving, also necessitates careful navigation to harmonize differing interests and leverage the unique contributions of each participant for the collective goal.

An agent's predisposition toward collaboration is largely driven by self-interest and prosociality. In large-scale societies, prosocial behaviors (i.e., behaviors that benefit others) often require collective facilitation or enforcement. This can occur through formal procedures or through the evolution of norm-based rewards and punishments (Fehr and Fischbacher 2004). The tension between self-interested and prosocial behavior affects the way in which agents strive to achieve cooperative autonomy: individuals may resist social influence yet honor their obligations to the group (Endicott 2011). For example, cooperative agents may acknowledge the need to collaborate with others to obtain food but withhold the right to choose with whom and to what extent they want to cooperate in carrying out a specific task. Consequently, understanding the balance and interplay between self-interest and prosocial tendencies is essential for designing effective collaborative systems and structures. When fostering

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collaboration in diverse groups, recognizing and accounting for these dynamics can lead to more harmonious and effective interactions.

Knowledge, Beliefs, Desires, and Intentions

Each agent's ability to engage in collaboration depends on cognitive factors (Woudenberg 2013) such as their attention, memory, and social reasoning abilities. For instance, the agent's information-processing capability (Proctor and Vu 2012) may constrain their ability to process information about the environment in which the collaboration takes place or learn about the plans, rules, and strategies of the collaborative work. Similarly, an agent's knowledge, current emotional state, and capacity to infer beliefs, desires, and intentions of other group members (Baker et al. 2017) may affect their ability to engage in social and/or collaborative work (Nichols and Stich 2003).

Agents are also constrained by their beliefs, which play an important role in guiding people's actions and social behavior (Denzau and North 1994; North 2005). An agent's beliefs may evolve over time as knowledge is shared among the collaborative group and as the success or failure of its collaboration are realized (cf. Rodriguez et al. 2016). Over time, the connections between beliefs can also change as information arises and knowledge crystallizes based on inference that agents make by tracing the connections between concepts (Rodriguez et al. 2016).

Belief networks can include knowledge or beliefs about the other members of the collaborative group. The ability to represent the state of mind of fellow collaborators critically depends on agents' abilities to mentalize, also referred to as *theory of mind* (Nichols and Stich 2003; Premack and Woodruff 1978). Tomasello et al. (2005) suggest that many of our species-specific types of collaboration rely critically on how well agents can make inferences about the mental states of others to predict their behavior and represent shared frames of intentions and action plans. These shared frames, mental models, and social conventions can reduce the cognitive load necessary to sustain a collaboration by transferring some of the cognitive burden from the individual agent to the group or collaborative architecture, including the material environment. For instance, modern traffic rules and roads facilitate collaboration between drivers by offloading the necessity to make complex inferences about other drivers' intentions. Recent research suggests that high risk, arousal, or frequency activities become conventionalized to facilitate successful collaborations without having to rely always on complex mental inferences (Freire et al. 2020a; Hawkins et al. 2019a).

Collaborative Affordances

Successful collaborations depend on more than just agents endowed with the capacity to form rich internal representations or models of others' minds.

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When collaborations unfold in a well-functioning architecture, the individual behaviors of the agents can be guided predominantly by the recognition of prespecified roles and activities *inherent to the architecture itself*, rather than the mental representation of goals and predispositions of other group members. This may be especially true when people communicate through material culture (discussed further below). We can thus think of collaborative architectures as creating *affordances* for collaborative action, within which agents operate, each endowed with their capacities for collaborations that are constrained or enabled by the collaborative architecture. Following the work of Gibson (1977), affordances are relations between our capabilities for action and the way the environment (material and social) meets these capabilities; that is, the extent to which we "directly" perceive the environment to allow or invite certain forms of (inter)action. If someone hands you a cup, you recognize the gesture and might reach out to grab it. This collaborative response does not require us to represent all the rich mental states and intentions of the handing agent. Rather, you simply recognize this *type of situation* to be one of handing-and-grabbing. In this sense, collaborative architectures can lift some of the heavy burden of situated theory of mind by providing easy-to-recognize scaffolds with predefined affordances for coordination. In other words, these collaborative affordances offer a scaffold that reduces the cognitive load on agents to continuously model and infer the intentions and mental states of all other participants, thus facilitating smoother coordination and collaboration. This may allow collaborations to succeed even though participants possess diverse mental models.

Group Size and Composition

Beyond the factors pertaining to properties of individual agents, group properties also affect collaborations. One such factor is the size of the group (Bonacich et al. 1976). Whether we are talking about a large group that has formed based on Sir Bevis of Hampton's idea, "*many hands make light work*," or a small group built on the grounds of George Gascoigne's notion of *"too many cooks spoil the broth*," both groups seem equally liable to success as well as failure.

Groups of different sizes may rely on different properties of the collaborative architecture. Whereas small groups often work well without structured or explicit rules of coordination (Olson Jr. 1971), larger groups tend to benefit from more explicit protocols to establish coordination, distribute tasks, and assign responsibilities. Importantly, however, even a casual dialogue between two people will typically be subject to an implicit coordination scheme in the form of turn-taking routines (Stivers et al. 2009), expectations of relevance (Sperber and Wilson 1995), and appropriate protocol (e.g., with respect to politeness; Brown and Levinson 1987; Gretenkort and Tylén 2021), which might only become apparent when expectations are violated (Goodwin and Heritage 1990).

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Group composition is another relevant factor in any collaborative activity. Although the structure of the collaborative architecture, as well as its affordances, are critically important for any collaboration, the combination of traits, experience, and skills of individual group members can be equally important for the success of collaborative actions. A small group of athletes rowing a boat might benefit from quite similar skills and experiences to ensure the maximal levels of action synchronization important to win a race. In other cases, such as complex problem solving, successful collaboration might require a combination of very diverse skills to succeed (Hong and Page 2004; Page 2007b; Sulik et al. 2022). Again, this implies that the group's composition matters, whether diverse or homogeneous. Moreover, collaborative performance cannot be predicted solely based on the additive capabilities of individual participants, as it emerges from the specific combination of complementary contributions, skills, and knowledge.

Environment

Environmental factors play a dual role in collaboration: they both affect the collaborative activity and are affected by its activities. Here, we mean environment to refer to the collection of physical and cultural structures within which collaborations take place but which are not reducible to the core components of collaboration itself (i.e., the task, actors, and architecture). Drawing from our coauthors' expertise, we describe three domains in which environmental factors affect and are affected by collaboration. First, we discuss the role of resource availability to illustrate environmental constraints. Second, we describe the practice of fencing in the Greater Mara, Kenya, to illustrate the constraints of material culture. Third, we consider the tradition of communal child-rearing in Cameroon to illustrate cultural constraints.

Environmental Constraints

Environmental constraints determine the space and affordances in which collaborations take place. Communities situated in a rainforest or in a desert, for example, engage in different collaborative processes driven by the ecological demands and properties of each ecosystem.

One of the clearest examples in which the physical environment constrains collaboration is resource availability and scarcity. Scarcity can both drive and hinder collaboration. Collaborations often arise in specific instances of scarcity or domains where scarcity occurs (Kumar et al. 2017; Lai et al. 2020). Water and food shortages may lead a community to create mechanisms or institutions for resource allocation. When scarcity results from poor management of a common pool resource, collaboration may become even more necessary but could be adversarial toward existing authorities or power structures.

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Conditions of scarcity at the individual or agent level can also be detrimental to collaboration because they limit the time available to collaborate and impose cognitive burdens (Mullainathan and Shafir 2013). For example, in rural India, one of the fundamental problems thwarting collaborations among women is simply that they do not have time to devote to new collaborative activities (Chapter 7, this volume). While collective political engagements could potentially improve personal rights of women or the needs of children, women are overburdened by social responsibilities, and they fulfill multiple roles as wives, mothers, and caretakers of the elderly and disabled as well as livestock and the natural environment (e.g., fields, water sources). The impact of scarcity on collaboration, therefore, reveals a critical challenge: when individuals or agents are constrained by limited resources, such as time, their capacity to engage in and contribute to collaborative efforts is significantly hindered.

The cognitive effects of scarcity have become an active area of research. Evidence shows that scarcity causes tunneling; that is, an extreme focus on the scarce resource or opportunity and neglect of other activities (Mullainathan and Shafir 2013). Scarcity also inhibits executive functions, time management, and decision-making skills (Zhao and Tomm 2018). It may also limit a person's ability to behave altruistically (Prediger et al. 2014). Each of these effects makes it harder to maintain or form a collaboration.

Material Culture

We are sometimes inclined to treat our material surroundings merely as a "context" for social interaction and collaboration, yet how we organize physical space plays an active role in shaping collaborative endeavors. Latour (1996) presents a thought-provoking example by inviting us to think about the social life in a chimp colony. Chimps live a complex social life. With no material support, they enact all their many social relations to fellow group members simultaneously (see Chapter 2, this volume). Only through their behavior can they manifest their role as leader, partner, parent, friend, or competitor. Humans, instead, have evolved material structures to help us offload some of these relational aspects onto our material environment. For instance, we build courtrooms where the judge is elevated from the floor to signify authority. We build walls that allow ourselves to be a parent in one space, a colleague in a different space, and a customer in a third space. In other words, material structures can do more than merely compartmentalize; they can actively orchestrate our collaborative interactions and group affiliations, situating them within distinct physical contexts that nurture and facilitate different types of relationships. This perspective on material culture challenges a categorical distinction between more intangible aspects of collaborative architectures (e.g., habits, social norms, institutions, and cultural practices) and the tangible physical properties of our environment. Through this lens, we see a seamless continuum that

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interweaves the intangible and tangible, highlighting the profound influence of our physical environment on the fabric of our social and collaborative lives.

A fascinating example of the codetermination between material configurations and human interactions can be observed in the historical and contemporary expansion of landscape enclosure and fencing, illustrating how these physical changes emerge from human activities while simultaneously transforming them (McInturff et al. 2020). This has happened across many parts of the world, including Asia, the Americas, Australia, Africa, and Northern Europe and includes major state-sponsored projects that have erected walls in the West Bank (Jericho), along the Mexican border, and in Hungary. Fences and physical boundaries provide powerful collaboration constraints that regulate access and privileges with respect to who has access to which parts of the land, kin, social obligations, and more. In the Greater Mara, physical landscape enclosures and fencing are recent phenomena, spreading rapidly across a landscape that was previously held as open grazing commons (Lamprey and Reid 2004; Løvschal et al. 2022). With little regulation, fences have spread like wildfire. Interestingly, however, is the fact that land enclosure is in no way a new process in this area; it occurred during the colonial era (1920–1963). After Independence in 1963, land was divided according to a regular grid, following Western Enlightenment principles of enclosure and exclusion (Løvschal and Gravesen 2021). This approach to land demarcation is integral to the broader state-making process, embodying the Enlightenment's emphasis on rationalizing land ownership and use through legal and physical boundaries (Scott 2010). Most of these enclosures, however, were physically invisible since they only existed on maps. It is only recently, primarily within the last decade, that parcels have adopted the physical form of fences. This new physical form has caused profound changes to the landscape for livestock and wild animals and is leading toward a rapid collapse of large-scale animal migrations.

At the same time, the ecological and environmental changes that have emerged because of widespread fencing have forced people to collaborate and consider new notions of the public good. For example, the fences secure and express rights to plots of land and create so-called grass banks that prevent free-roaming livestock and wildlife from eating the grass. Emerging land tenure hybrids, including semi-commons and mixed forms of collective governance, are being created at the interface between the formal statutory governance and customary land tenure. One example of these emerging hybrids is the community-based forest management initiatives in Nepal (Baland and Platteau 1996). These initiatives blend traditional communal land management and formal conservation efforts—local communities play a central role in managing and protecting forests—and demonstrate a successful model of collective governance that balances the needs of the community with environmental conservation objectives.

The widespread adoption of fences, therefore, provides an interesting example of the delayed and long-term consequence of imposed collaborative

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architectures. These physical demarcations not only showcase how physical alterations to the landscape can have profound long-term effects on social and environmental interactions but also emphasizes the potential for these material changes to redefine collaborative dynamics by introducing new constraints and possibilities. This scenario reveals the intricate dance between physical and immaterial aspects of a collaborative architecture, demonstrating that the structures we create and interact within can profoundly influence the patterns and possibilities of collaboration.

Culture

From an anthropological perspective, culture encompasses knowledge, symbols, language, beliefs, values, actions, capabilities, and artifacts acquired by an individual as a group member (Tylor 1871/2010). As such, culture can be expected to be associated with all aspects of collaborative architectures.

Among the Nso' people of the Northwest Region of Cameroon, collaboration is a way of life. It is present in every aspect of their daily lives and is rooted in their belief system, captured by the Lamnso' proverb: *wir dze wir, bih wir* (I am because we are) (London et al. 2014). Cooperation in domains such as child-rearing, farming, worship, and marketing results in nearly ad hoc collaboration (Yovsi 2014). For example, a farmer on her way to her field stops by the home of another farmer to let her know that she is going to tend to her crops. Gradually, these visits become a daily occurrence. In admiration of these interactions, neighbors join in; this eventually leads to the joint cultivation, harvesting of each other's fields, and the work to store the harvest in barns. The cooperation involved in carrying out these activities is marked by unique cultural connotations rooted in shared meaning and understanding of the Nso' belief system (Yovsi 2014).

Driven by their cultural belief system, the Kurumbas and Mudugas of Attappadi (now living in Kerela, India) collaboratively perform symbolic rituals to send the souls of the dead to the spirit world, a practice also known as "the secondary funeral" (Poyil 2009). Accompanied by singing, dancing, and blood sacrifices, this ritual depends on the collaboration of all community members. It begins when key community members recreate the deceased figure and place it in a funeral car; relatives (mainly women) and female mourners sit around the car and wail in agony, while other community members dance around the car for three days and three nights. On the third day, the figure is taken out and cremated, thus marking the end of the secondary funeral—a ritual that is defined, shaped, and driven by culturally shared beliefs.

Socialization goals in child-rearing are not constant around the world. Some parenting practices aim at autonomy whereas others focus on interdependence, and each parenting style impacts the emotional and cognitive development of children (Keller et al. 2005; Levine et al. 1994). When children are encouraged to cooperate with others to complete a puzzle or task, this may foster

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collaborative interest in other tasks. By contrast, when children are encouraged to search for solutions independent of others, this may lead to egocentrism. Across cultural groups, Stengelin et al. (2020) have shown that children display more cheerful attitudes when performing a task with peers than singly. Some children perform better in large collaborative groups in cultures that exposed them to larger group tasks.

Concluding Thoughts

In approaching the question of how people collaborate, we have considered wide-ranging collaborative activities in different areas of the world, which were supported by different collaborative architectures. The diversity of goals, tasks, and contexts involved point to variations in how agents respond. In addition, the variety of material and cultural environments in which collaborations take place lead to the observation that collaborations are complex adaptive systems that change continuously over time and adapt to and shape circumstances.

Given this variety, it is unrealistic to expect that successful collaborations will take on a single form. Collaborations do not, in our view, satisfy anything like the *Anna Karenina Principle* (i.e., every one of a set of factors must be present or failure will follow). Our conclusion is that successful collaborations do not need to be alike. They can have rigid or loose rules. They can have a hierarchical or flat structure. They can involve a group of people who pursue a single goal or people with diverse interests. Thus, to attempt to find empirical correlations between features of "how people collaborate" and success requires interacting those features with tasks, contexts, and sensitivity to time.

That said, all "happy" collaborations may be alike in two fundamental aspects. First, their architectures align with their tasks. Collaborations among small groups of people that require equality of voice tend to be flatter, less formal, and less rigid. Larger collaborations often break a task into parts and, in doing so, create a hierarchy with distinct repertoires. Second, the knowledge, tasks, connections, and communications within a successful collaboration respond to internal and external feedback, producing path dependence in internal structure, outcomes, and changes to the material environment. Therefore, successful collaborations are those that develop the capacity to evolve and to learn.

Building on this reasoning, we can infer that a collaboration, like any evolved entity, may include features that appear messy and inefficient but may be crucial to its adaptability, resilience, and success. In sum, as Heraclitus would say, the only fixed rule for how to collaborate is to allow change—to create an environment that allows (a) participants to harness their collective capacity through perpetually originating thoughtful adaptations toward organized, effective solutions and (b) the collaboration to evolve and adapt to changing circumstances.

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