# The Nature of the Project

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## Abstract

Projects are likely ancient and rooted in human sociality which allows people to reliably generate project-like structures. The project is a recurring and orthogonal structure that augments firm hierarchy and is activated to solve problems perceived as too complex for the firm. Just like human working memory, projects focus and coordinate distributed resources and are not just akin to human working memory, but are governed by and hence recapitulate working memory and social problem solving dynamics. Projects may be limited in their size because of known limits in working memory, mentalizing and social problem solving. The implications for recasting projects as firm working memory are significant and should cause firms to deemphasize the causal, deterministic mindset that permeates project management in practice today. Conceptualizing projects as complex, problem-solving, multi-level social networks with dynamic and stochastic properties can improve project success but will require significant shifts in preparing for, activating, planning, measuring, monitoring and controlling projects. As we rethink project management, ongoing research and practice along these lines is needed.

By all accounts, what we know as a project is a 20th century phenomenon. Project management began as a new discipline in the late 1960s in the construction, defense and aerospace industries as consultants, industry and governments had to grapple with large, complex and temporary endeavors. Program and Evaluation and Review Technique (PERT), a tool for representing and analyzing tasks in large complex projects to determine project completion and Critical Path Method (CPM), an algorithm for determining project completion timelines were developed in the 1950s and are both commonly used today in project management.

The growth and establishment of project management proceeded rather quickly over the next few decades. The Project Management Institute (PMI), which is the premiere project management consortia globally, was created out of Georgia State University in 1969 as a non-profit organization. In 1996, PMI standardized the project management practice with the first publication of its Project Management Body of Knowledge (PMBOK). A decade before that, the PMI launched its first practitioner certification, the Project Management Professional (PMP) in 1984. In the United Kingdom, the project management standard Projects in Controlled Environments (PRINCE2) was adopted in the 1980s. These two certifications achieved recognition as ANSI/ISO/SEC accreditation standards in 2007 (Turner, 2010; Project Management Institute, n. d.).

Within 60 years, project management progressed from an embryonic state trying to contend with the large modern projects of the day to a full-fledged discipline with standards and certifications, books and research galore, different philosophies and tools and hundreds of thousands of practitioners worldwide. As a result of all this growth we tend to think of project management as a relatively recent and major addition to the management toolkit. Project management thinking has successfully invaded 20th and now 21st century management thinking writ large.

But is a project so modern?

What we know as a project in practice, that is, a temporary grouping of people who work together to achieve a goal, is quite old and is part of our DNA. It is very likely that human brains evolved principally to accommodate more complex social arrangements. These complex collaborations, greatly facilitated through expressive language, proved vital to and wildly differentiating for our success as a species (Gowdy & Krall, 2013). The social brain hypothesis suggests that the reason human brains grew relative to other primates was to facilitate complex social interactions and collaborations that supported and ignited Homo sapiens success (Dunbar 1998, 2003).

I believe our fluid understanding of a project in practice draws itself from this genetically embedded social cognitive ability and thus the project is also ancient. Coordination of temporary teams of people for hunting, defense, warfare, and trade have existed since the dawn of humanity. While the codification of what we know as the project and project management is very recent, the innate and tacit ability for people to work in projects isn't and as a result of this innate skill, humans can reliably replicate projects and naturally self-govern them. While the 20th century codification of the project management

discipline greatly advanced projects and made them tractable, causal, computationally analyzable, manageable and more sophisticated, it did not create them.

Like other realms of inquiry in the social and psychological sciences, project management has had and continues to reconcile different perspectives and explanations of what exactly is a project and what makes for a good one (Winch, 2004; Svejvig & Andersen, 2015; Padalkar & Gopinath, 2016; Kertzner, 2017; PMBOK 2018). These different perspectives range across different levels, from the highly abstract and logical realm of algorithms and simulations to the social and cognitive psychology. The description of a project here fits more squarely into the social and cognitive layers of project analysis. Since innate human behavior tends to fall into repeatable patterns, project managers can monitor and measure human behavior and from there, infer project health without needing to fully reveal the intricate logic of the technical aspects of the project itself. The approach advocated here is not fully deterministic, nor is it fully probabilistic but it stands much closer to a non-causal and probabilistic approach rather than a fully deterministic and tractable approach, hence the use of the term 'statistical' in statistical project management (SPM) (Kellen, 2019). Since in SPM the basis for many project health inferences can be drawn from a simple lists of tasks to construct objects, without technical or other dependencies, it would not be unfair to call out SPM as an anthropological behavioral analysis of the human tribe working in projects. Thus, the thoughts here about what is a project and why it exists is cut out of this non-deterministic and social cognition cloth. But to understand a project and why it exists, we must first turn to firms to understand why they exist. After all, projects at least most of them, are in the service of firms.

## Projects and Firms

Ronald Coase's 1937 seminal paper on the nature of the firm has fostered continued inquiry from scholars as to why firms arise in the first place and what is their nature. Standing here in the 21st century, we take for granted the many types of business entities – firms – that dominate the economic landscape and in daily practice we don't question their origins. Since the publishing of Coase's paper, many scholars have outlined several theories about the nature of the firm, why it exists and how it ought to be conceptualized.

The critical point in Coase's 1937 paper is that marginal cost and pricing mechanisms, concepts used to describe markets, can be used to explain why firms exist. Firms exist to reduce transaction costs and risks below that which a market pricing mechanism can accomplish, such as the cost of negotiating independent contracts with workers or the cost of price negotiating with suppliers for things the firm might produce itself at less cost. Firms can absorb the risk regarding uncertainty on future prices and future tasks that might need to be assigned to employees by hiring employees rather than renting them periodically from the market. Rather than contracting with employees in a market with codified activities, firms can reduce transaction costs with, a simpler and more flexible description of activities. Firms can reassign work without adjusting contracts. While markets may be efficient, they are not perfectly so. As firms lower transaction costs below the market, they incorporate those activities within the firm. Conversely, when the costs of doing those transactions within the firm rise to prices found within the market, as they would according to marginal cost theory, those activities are more like to be transacted in the market, not within the firm. While this is intuitive enough for us, the insight here is that the nature of the market (which involve things like pricing mechanisms and marginal cost) spurs the creation and the evolution of the firm.

An alternate way to look at this problem is that firms are better at some things than the market. Getting ideas into a marketplace can be difficult because the knowledge at play is tacit and hard to share or explain with others and if it is explainable, then knowledge can be expropriated by others. Firms let firm leaders bring ideas forward in private. Because of the more enduring nature of the firm rather than the ephemeral nature of market transactions, firms can be better than markets at motivating and allocating employees. Firms can control intellectual (and other) property better than markets. The ambiguity and complexity that arises naturally out of property rights agreements in a market creates risk for a single entrepreneur and gives firms an advantage since those property rights are now not traded in market and held close. Markets fail to accommodate these kinds of transactions, or if they do, firms find ways of doing them better than a market of individuals. This allows firms to occupy their niches in markets (Pitelis & Teece, 2009).

Lacking a superordinate organizing agent, markets are by their nature uncertain. If firms are to survive, they must deal with the various market players around the firm, including customers, suppliers, employees and the market at large. Firms engage in a dynamic process of co-creation with these other players in planned and unplanned ways. Because market and firm interactions are highly dynamic, firms need more efficient adaptation skills that can focus externally (e.g., market sensing and product or service innovation) and internally (e.g., diagnosing and improving firm capabilities, assets and

business processes). Markets don't direct their improvements and actions, but firms do — the visible hand of management supplants the invisible hand of the market (Powell, 1990). Firm leaders are the principal agents in managing the co-creation and adaptation processes when they come together in teams to diagnose, configure and use knowledge assets and organizational capabilities in new ways. Principals of the firm capture value within the market innovative activities and from routine operations of the firm (Pitelis & Teece, 2009). Firms don't come about just because they can lower transaction costs further, they come about because firm leaders need to extract value from the dynamic, uncertain and emergent processes at work in markets.

Implicit in these explanation of why firms exist are two core concepts. First, the firm has a structure and means of operation different from the market. The firm structure displaces the market structure. The firm, as a structure, bypasses the market for certain transactions and activities chiefly to lower costs or risk and to capitalize on tacit knowledge. Second, that there exists a hierarchy of sorts between principals of the firms (firm owners, entrepreneurs, leaders) and the employees of the firm and other assets that stands in contrast to the fluid network structure of a market. This hierarchy has some efficiency and adaptability benefits. Above all, because of innate and complex human sociality, the differences in structures within markets, firms and projects show the remarkable adaptability and flexibility humans have with different social structures to solve different problems. By examining structure, the role projects play relative to firms becomes clearer.

## Why Do Projects Exist?

Just as firms displace the structure of markets, projects displace the structure of the firm. But why do firms need projects? And how does their structure differ from firms? As markets have evolved in the past century or so, the level of dynamism and change within those markets has grown as well as the attendant size and complexity of firms. Firms have had to adapt quicker. Projects further extend a firm's dynamic capabilities in ways the firm as usually constructed does not. By coordinating access to various resources without upsetting current firm activities, projects exist to help the firm continue capture value from both its innovative market co-creation activities and its ongoing operations activities.

Given the urgency and increased dynamism of market demands and the temporary, nature of projects that human sociality makes innate, it makes sense that firm leaders and employees would turn to projects to orchestrate larger change. Projects in practice typically do bigger things more quickly than the firm would otherwise. Projects reconfigure the firm's human resources, functional capabilities, daily activities and firm knowledge to respond to threats or opportunities in the external environment quickly, especially if the resources needing activation are broadly distributed across the firm and harder for the firm or orchestrate. In these dynamic contexts, projects represent an alternate and temporary structure to the dominant firm structure that can be activated more quickly than trying to rearrange the existing firm structure. As a result, we see in practice firms using projects in innovation and market-sensing contexts (e.g., new product development or market research) as well as in routine operations (e.g., cost-cutting or continuous improvement). Projects exists to reduce firm transaction costs and extract value from dynamic markets. They exist distinct from the firm structure because they are temporary and allow the firm to avoid reorganization costs and risk.

## How the Project Structure Differs from the Firm Structure

The project is a more recent evolutionary firm adaptation that complements the firm hierarchy rather than supplanting it. Firms evolved hierarchies in order to provide efficiency and some adaptability while maintaining stability. Firm hierarchy, especially its division of knowledge and labor into different disciplines is a necessary arrangement to achieve the benefits the firm seeks: decreased transaction costs and access to specialized knowledge and skill. Continued operations relies on these specialized skills to be well orchestrated. Due to information processing limits of human beings, all people cannot be experts in all things, especially when it may take a decade or longer to achieve skill in just one discipline. Employees need to be placed within disciplines to cultivate the knowledge and skill needed for firm success. Thus the hierarchy provides firms with an advantage: improved specialized skill and knowledge which translates to increased efficiency (Bolton & Dewatripont, 1994). With the divisions of labor and knowledge in the firm, these skills can be more quickly extended and improved without affecting other parts of the firm. Semi-isolated, localized and specialized capabilities have strong benefits. But that hierarchy also comes at a price.

Some changes exceed the capability of the hierarchy to absorb. In order to diagnose, configure and rearrange the firm's knowledge assets and organizational capabilities, the firm may need to undo, extend or rearrange partially or substantially the very structure that gives it its strength. Even if the change the project seeks to produce is not applied inward, some

problems still can exceed the capabilities of the firm to solve. In this regard, reconfiguration of the firm has high "transaction" costs that projects help avoid. Individual relationships, learned repertoires of processes and interactions between people and information systems, retention of critical employees and employee motivation are at risk during episodes of significant change within firms. Even if these aren't at risk, a significant change may require too many employees to formally bring into the firm and may not be needed beyond the lifecycle of the project. Just as ancient standing armies used mercenary armies, firms use outside "surge" resources for projects that exceed firm capabilities. Not only does the project activate these resources, it does so in a manner less challenging to the organization and at a lower overall cost, psychic or monetary, for the firm.

At its most primitive level, one can think of a project as a modern hunting party. Whatever the structure of the Paleolithic band of humans at camp, the hunting party forms and assembles a new structure that does not directly challenge the pre-existing family and band structure. The hunting party goes out, achieves (or not) its goal and returns back to the existing band structure. It makes great sense than any enduring hierarchy of humans, however deep or flat, would seek to conserve the level of change and avoid the uprooting and replacing of existing hierarchies or power relations. That would destabilize the tribe. Today's human beings, endowed by our ancestry for being both hierarchical and anti-hierarchical at the same time (Boehm, 1999), would find it quite natural to slide between two structures especially if the newer structure was temporary and non-threatening. In essence, we are designed by nature to accommodate complex social relationships, both hierarchical and anti-hierarchical and at the same time. Projects are an innate extension of our sociality.

This depiction of a project can differentiate between two types of projects, or two ends of a continuum:

1. Projects that exist to create value of some kind to be delivered outside the firm to another firm, an external client or customer, but what is called here the superordinate firm. Firms that sell projects to superordinate firms (client forms) make their living from project management. The firm perceives the the knowledge or change sought isn't considered strategic or valuable to hold within the firm or the knowledge or change can't be reasonably placed inside the firm.

2. Projects that create something or effect a change that is placed within the firm itself and consumed or used by the firm. In this type of project, firms use projects to create value or effect a positive change within the firm. The firm perceives the knowledge or change sought is strategic or valuable and needs to be placed in the firm.

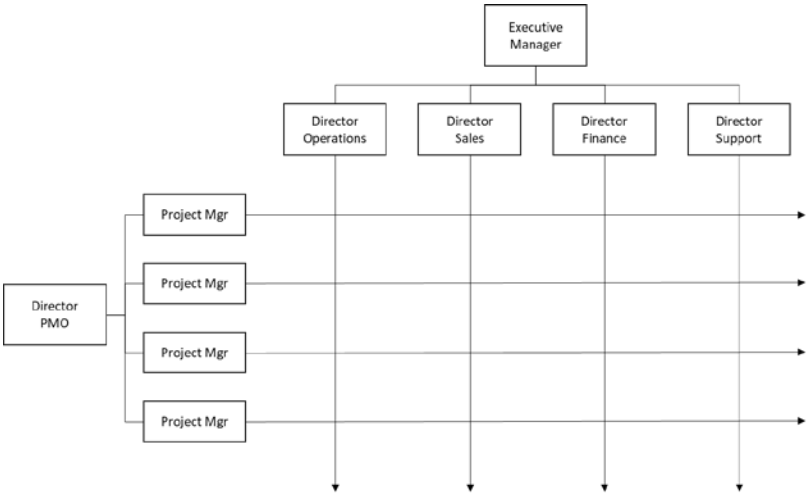
Projects related to home buildings and movie studios are type 1 projects. The superordinate firm creates the projects to bring together disparate resources within a temporary structure. What the project creates is largely used or consumed by other firms or end-users. This lowers the superordinate (the paying) firm's cost of paying for idle time and management overhead for maintaining these disparate resources in between projects. In the case of movie studios, while actors, directors and other creative staff may maintain long-term relationships with specific studios or even placed in a long-term contract, much of the talent in construction and movie projects are temporarily contracted by the superordinate firm. In these projects, the knowledge embedded in details regarding the project product or change are not required to remain in the firm. Those knowledge assets can be "rented" in the future.

In the second case, a type 2 project, an example is a firm selecting and implementing a large enterprise information technology system. This type of project brings together resources both inside and outside the firm, but to effect a change within the firm. In the type 1 project, significant knowledge may not need to be deliberately created and preserved within the firm as a result of the project. In the type 2 project, a primary purpose for the project is to create and retain within the firm knowledge related to the output or change desired, like critical knowledge of new processes and technologies. While some of the resources are temporarily contracted just like in type 1 projects, in type 2 projects the emphasis on effecting change of some kind within the firm is greater.

Projects displace the firm structure, specifically, the hierarchical aspects of that structure, in what is usually called a matrix structure. The PMBOK outlines the relationship between firm structure and project structure as fully orthogonal (Figure 1) with project teams cutting across different parts of the firm hierarchy in a matrix-style structure (PMBOK, 2018). While perhaps simplified, with many nuances and variations in organizational structure omitted, this model also makes practical sense. Projects frequently access borrowed employees from different parts of the hierarchy and place them in the project structure where they can be activated (engaged, motivated, coordinated) more easily. The head of the project management office (PMO) now sits on top of an alternate hierarchy that is usually perceived as temporary and limited in terms of how it

can adjust critical aspects of employee relationships (e.g., firing and promoting), so the project is reasonably non-threatening to the dominant firm structure.

Figure 1. Matrix project organizational structure




The notions of hierarchy, matrix and network structures described here are highly stylized and partial descriptions for what actually happens within markets, firms and projects. In the real world, humans are quite adept at establishing and maintaining many types of relationships simultaneously. Portions of markets often have long-term relationships between firms that extend well beyond the transaction into subtle forms of enduring hierarchies. Firms may contract with legal firms over much longer periods of time than they do with key employees (Powell, 1990). Within firms, the hierarchy, while dominant, is usually not the only structure in place. Firms often have dual-reporting relationships of matrix structures which represent multiple hierarchies in place at the same time.

Individuals within the firm usually maintain informal relationships that sidestep the formal firm structures. These informal social networks co-exist with the firm structure but are frequently obscured from managerial view. To meet the demands of the tasks and changes at hand, people form and reform these complex informal structures periodically. While these informal structures are usually beneficial and natural, they have their limits depending on the scope of the change needed. Projects have a more formal structure than these social networks and operate under tighter managerial control. A loose, but connected federation of individuals held together by interpersonal relationships is usually insufficient for bringing out broader and more substantial change. Projects are well-regulated; social networks within firms are not. Projects can be staffed with resources inside or outside the firm (or anywhere in between). Thus projects can lower transaction costs or improve extracting value in markets in a few ways: a) avoiding loss of efficiency and profit due to organizational disruption, b) using employees temporarily in an ephemeral structure rather than hiring permanently, c) loss of future market value due to firm delays, especially in dynamic market environments with short windows of opportunity. Projects help firms minimize the impact on the formal and informal structures that are important to the firm's ongoing operations.

For cost and innovation reasons, markets give rise to firms and firms give rise to projects. The nature of the market with its dynamism and the nature of the firm with its modular, hierarchical specialization spurs the creation and evolution of projects. This recurring or episodic relationship between the project and the firm brings to mind a rhyming metaphor that sheds new light on how firms and projects behave. Nature has found interesting structures to deal with similarly complex coordination problems and in this case we need look no further than the human mind.

## The Project as the Firm's Working Memory

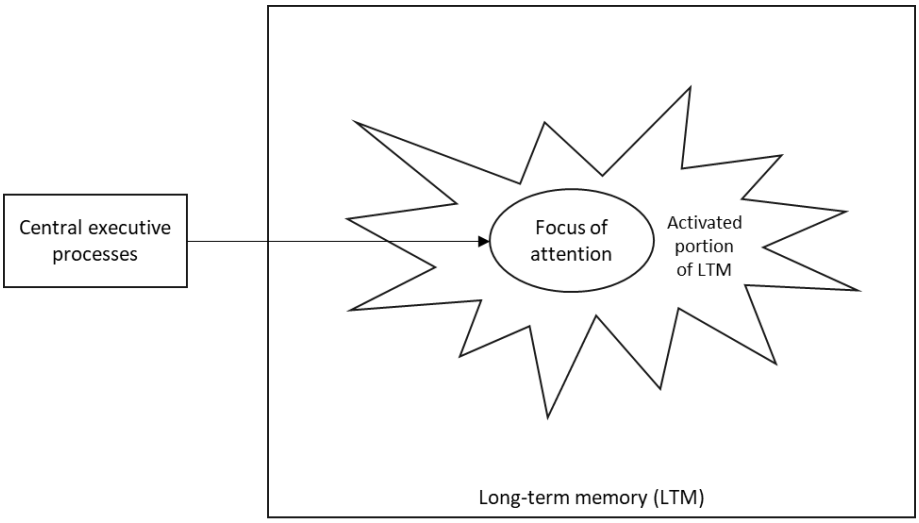
In humans, memory is usually divided into three categories: long-term, short-term and working. Short-term memory can hold a very limited amount of information at a time and for a very limited amount of time, acting as a buffer to hold mental representations momentarily. It can function without our conscious awareness of it. Long-term memory is a vast store of knowledge. It is the home to our memories, skills, knowledge and personality. It is stable and if cultivated over time, it is

the source of our expertise in any discipline. When we go to school or receive training, if we learn well, that knowledge is transferred to our long-term memory and becomes available more easily, especially with repetition.

Working memory helps humans, albeit after some measure of mental effort, solve more difficult problems or make more difficult judgments. Although working memory uses short term memory, it is distinct from short term memory and serves a different purpose. Short-term memory has transient "buffers" to hold information briefly, which working memory manipulates. We use working memory to hold and manipulate things in our mind as we solve problems or process complex information.

For example, when doing math problems in your head, your working memory holds and processes numbers and relations (mathematical operators) to determine the result. Your working memory sequences the activities while you are maintaining the information in your mind. When reading sentences, your working memory is holding representations of words and their grammatical relationships as you read sentences, especially if what you need to understand at the end of the sentence involves something at the beginning of the sentence. Working memory is heavily tasked on complex problems, which typically involve four or more independent items simultaneously. In learning, nearly all our knowledge must pass through the operations of working memory in order to be transferred to long-term memory. Hence, working memory helps to "rewire" connections in long-term memory by selectively activating portions of long-term memory as we work to learn the new skill or fact at hand. Working memory provides the effortful attentional focus as well as the computational space to manipulate. Figure 2 below depicts the relationships between working memory, short-term memory and long-term memory (Ricker, et al., 2010; Cowan, 2000, 2017).

Figure 2. Working memory model in Cowan (2017), Ricker, et al. (2010)




The central executive is a critical function of our working memory system that directs our focus of attention and coordinates sequences of mental operations. The central executive uses the activated portion of long-term memory to maintain information needed in problem solving and as such, the activated portion serves as a form of short-term memory. The activated portion of long-term memory is activated only temporarily. Despite the rather enormous capacity of our long-term memory, working memory is significantly limited in its "chunk" capacity, that is, how many "chunks" or "bundles" of information it can manipulate, each independently and at the same time (Cowan, 2000). In humans, that capacity is limited to about four independently interacting elements or chunks. For example, in remembering a phone number made up of three parts (555-246-3113) it is common for people to break the seven digit number into the three chunks and use mnemonic tools to further condense the parts into more easily recalled and manipulated bundles (e.g., the first chunk is three 5s, etc.).

With the central executive providing attentional focus, new associations between activated portions of long-term memory can then form in the focus of attention. Our working memory lies in the dynamic interplay between the central executive and the focus of attention itself (the activated portion of long-term memory). As depicted here, the central executive helps "rewire" our brain by firing neurons under our effortful conscious control within the focus of attention. This process is the primary means by which we learn. When we repeat a skill, physical or mental, the activated portion of long-term memory

undergoes a chemical change which binds the different portions of long-term memory into a new and with repetition, a more permanent association. We learn new things when our attention focuses our mind on repeated patterns of activation with enough iteration in order to rewire the connections. This repeated activation of connections in the activated portion of long-term memory enables us to form new memories and draw additional connections between memories.

At the heart of brain anatomy is an extraordinarily complex set of functional modules that provides efficient specialization and an equally complex set of connections between those modules allowing the basis for automatic and conscious coordination (Mastrandrea, et al., 2017; Bullmore & Sporns, 2012). Working memory serves a critical role in allowing recruitment and coordination of spatially distributed resources under deliberate conscious control. In conscious learning contexts, a chemical rewiring of connection strengths between and within these functional modules takes place. In a non-learning context, all the above occurs, often more automatically with less working memory control. Learning may occur in these contexts without conscious control so long as the emotional saliency or repetition of the activation is sufficient to effect the long-term neurological change. Repeating a series of activities without much conscious effort or experiencing an accident is an example of this kind of non-learning context. Another example is in novel problem solving when we fail to learn how we solved the problem and hence when we run into the same problem in the future, we tackle it anew. We failed to memorize our solution sufficiently.

Projects work in both modes: a learning and a non-learning mode as well as at any gradation across that continuum. For example, firms frequently outsource construction projects to construction firms because they do not have the skill of the construction firm. Doing the work internally would cost too much or taking that skill in-house would not align with the firm's strategy. According to the various theories of the firm, those activities will be provided by the market. Prior knowledge for the firm affects the form of project and resource control. Firms with staff already highly skilled and well-rehearsed in the project area will require less effort and will be more successful than those that do not have the same level of skill. In type 1 projects, firms typically outsource the project activities since the knowledge does not need to be retained or cannot be easily added. In type 2 projects, the knowledge the project generates needs to be added to the firm's stock of knowledge, regardless of whether project management is outsourced or not. Both types of projects can be addressed within this framework.

Projects and more specifically, the project management office, serve in ways similar to working memory's executive function by being able to coordinate disparate resources and provide attentional focus. And like exercising working memory, which requires effort, projects require additional effort (resources) to be able to coordinate the different resources arranged across the organization. The connectivity between brain regions under working memory control is akin to the matrix relationship between staff within firm capabilities and the project management structure.

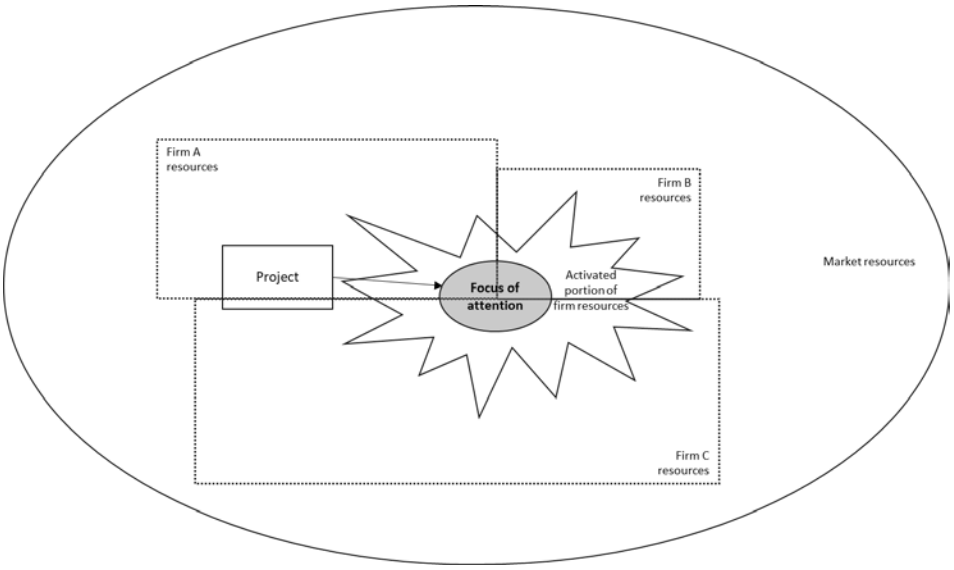
Summarizing, projects share key attributes with human working memory:

1. The firms stock of knowledge, captured within the dominant firm structure, is akin to human long term memory. That knowledge is distributed across the firm and the brain in specialized modules. Module efficiency is aided by the module hierarchy.
2. Projects activate resources across the firm (or multi-firm) structure just as the central executive activates portions of human long-term memory. Projects help the firm maintain focus and coordinate the distributed resources as the central executive does for people solving problems.
3. Just like working memory, projects can operate in a learning mode where new patterns of associations between distributed resources are established through the focus that the project management structure provides. With repetition, the firm long-term memory later can absorb the training, reorganization and other forms of organizational development efficiently. Similar to working memory, projects can also work in a non-learning mode whereby the firm merely solves the problem at hand without altering its long-term stock of knowledge or structure.
4. The entire project superstructure can include a complex collection of firm units or modules hierarchically arranged within themselves but connected to each other via both the dominant firm structure and the orthogonal project structure as well as in the myriad of ways people can connect with each other in informal social networks. For large projects, this superstructure is a very complex network structure of specialized modules, as is the human brain.

Visually, the project can be depicted as a "central executive" function that coordinates the activation of resources in multi-firm's structures (Figure 3). In this diagram, the project and project management function serves as the central executive

that is activating resources in three firms. Firm C is the superordinate (paying) firm, and has chosen to outsource project management largely to firm A, proving some of its own staff to the project management team. For this project, firm C is also utilizing its own resources beyond project management. Firm B participates in the project, with resources being activated and orchestrated by the project management team. The purpose of this diagram is to visually show that resources can be activated anywhere across multiple firms and the location and composition of the project management function can vary.

Figure 3. The project as a central executive activating firm resources




If you stand back a bit, the overall multi-firm superstructure is a complex mix of modular hierarchical structures working together in a large network. Two factors may be shaping this super-structure. Hierarchies deliver specialization and efficiency (Grant, 1996; Bolton & Dewatripont, 1994) and networks give access to a distributed collection of resources (themselves likely hierarchically arranged). Firm hierarchy provides efficiency and skill development and the firm social networks may help facilitate information exchange broadly (Reagans & McEvily, 2003). When you add the project structure to the mix and consider multiple firms working together, one can see that projects are very complex network entities. Complex networks like these exist in many domains including, but by no means limited to, biology, neurology, chemistry, sociology and information processing itself (Newman, 2018; Dickison, et. al, 2016, Bullmore & Sporns, 2012). All of them help with complex adaptive responses and similarly, the project gives firms additional adaptive capabilities.

Projects fill an important niche. They bridge the gap between a wider array of not easily accessed distributed resources and the need to efficiently coordinating those resources in action. It is as if there is a universal three-way constraint at work between a) gaining broad access to distributed resources, b) maintaining sustained, coordinated and selective attentional focus on those distributed resources and c) using the efficiency of hierarchies in long-term stores of knowledge when solving problems and implementing action. When the overall problem for the firm is too complex, a working memory of sorts, is needed. Once the problem has been routinized and committed in long-term memory in the appropriate functional modules with their attendant hierarchical structures (or by design, forgotten), the need for the project dissipates.

## Definition of a Project

With the metaphorical linkages between a project and human working memory clearer, the definition of a project follows forthwith:

> A project is a recurring structure, orthogonal to the firm that coordinates distributed resources to solve problems perceived as not easily solved with the current firm structure.

Projects are orthogonal in that they cut across the formal firm hierarchy. They are recurring in that they are temporary but repeatable. Projects are activated to address problems that are perceived by the firm as exceeding the capability of the dominant firm structure. Projects can solve problems inside the firm and outside the firm and can optionally involve

effecting a more permanent change or a type of organizational learning within the firm itself. Just as humans can use working memory to solve complex problems without committing to memory how they solved the problem, so too can firms do the same. Firms can also initiate projects to learn new skills. For example, a firm can crate a project to design a new product and bring it to market that includes tasks for developing new organizational routines (processes), possible reorganizations, changes in IT systems and culture changes needed in order to service that product once released.

While working memory is often thought of as activating resources within one mind, projects can activate resources or capabilities within many minds, both inside and outside the firm. This definition of the project does not demarcate where those resources or capabilities reside, or for that matter, whose "central executive" or project management office is activating those capabilities. Thus a project is essentially a social working memory capacity for coordinating the activities of many minds and across many firms.

## Project Activation and Control Factors

Projects require additional effort and are less efficient than the normal firm hierarchy, so firms activate projects selectively. When that activation occurs is a function of four aspects of complexity that characterize the full shape of the problem at hand: problem novelty, problem complexity, environmental complexity and organizational complexity. These four factors are useful categories to not just think about how a firm decides to activate a project, but how a firm controls the project during its lifecycle.

### *Problem Novelty*

Novel problems are ones the firm has not encountered before or for which the current capabilities are not able to solve the problem at hand. The mismatch between the nature of the problem and the firm capabilities can occur because the capability is not present at all or the firm perceives it is too hard for the firm's default mode of operation to tightly coordinate the needed distributed capabilities. Firms that tackle problems with low novelty are more likely to have existing firm capabilities that they can bring to bear within its existing structure. Problems with high novelty often exceed the firm's current capabilities or overwhelms the current firm structure. The higher the novelty of the problem, the greater the likelihood the firm will activate a project since the current firm perceives it does know how to solve the problem. For projects with novel problems, the firm might not have any methods available for solving the problem. In these cases, new problem solving methods are more likely to be invented and deployed within the project. Humans do the same.

For novel problems in learning contexts, the firm often has a need to embed what the project learns into the existing portfolio of firm capabilities and know-how with, at times, significant adjustments to its structure. Firms with low prior knowledge may need to build their stock of knowledge beforehand in order to more easily absorb what the project is attempting to change or create. Firms can reach out to external suppliers of that knowledge, but to the degree that knowledge has to be embedded in future firm capabilities, the firm will need to absorb that stock of knowledge at some point. Firms with a significant mismatch between firm capabilities and the nature of the project's problem will have to spend more energy (cash, time, attention) than firms with a greater match between the firm capabilities and the nature of the project's problem. Firm that can build those capabilities before a project is activated will spend less energy on the project and are more likely to succeed in that project.

### *Problem Complexity*

Problem complexity refers to the number of independently interrelated parts or components within the project problem. Here, the project problem components refers to technical pieces of the project itself, independent from human organizational and external market complexity. For example, making mayonnaise as a problem has far fewer independently interrelated components than making a jet airplane. But both have technical components independent of the human skill involved in making either. By independently interrelated I mean that no component of consideration can be easily subsumed within the other ("chunked"). This results in components that will have divergent but interacting behavior requiring high expertise to understand them individually or joined together. Some projects have a high number of independently interrelated parts that need involvement of many human capabilities that are not well connected or readily available to the firm. For example, an accounting system project may require multiple, normally isolated units when making changes within a chart of accounts, including accounting, compliance, risk management, operations and IT.

Projects also can have many dynamic and uncertain technical components. For example, an IT project may need to use a technology that is emerging for which the technology itself is changing monthly or weekly. Some projects may have such a large number of technical components in them that even with perfect serialization of tasks and limited interaction effects, their size makes them unwieldy, requiring a larger project structure with additional resources than the firm normally possesses.

Problems that are complex will have a large number of interrelated parts, may have parts that undergo significant revision throughout the problem-solving process and will also have a very high level of anticipated effort to solve. Problems with low complexity have fewer interrelated parts, are stable over time and have a small scope of effort. When the number of interrelated parts is high or the problem is big, firms are more likely to activate a project structure for these complex problems in order to better coordinate existing firm capabilities. New methods of work and orchestration of resources are frequently needed for complex problems. Once the complexity is mastered in the project, the firm may be able to transfer what the project learns into the existing set of capabilities within the current firm structure. In short, once a firm masters complex problem solving within projects, that knowledge may pass to the firms "long term memory" and its regular structure, enabling more efficient use of this new knowledge.

Problem complexity interacts with problem novelty. Firms with a high levels of ability in a project problem domain are capable of managing more complex projects because they have routinized many aspects of project management or project construction. Just as people with high domain knowledge see problems as trivial that people with low domain knowledge see as difficult, firms with high domain knowledge or skill see some projects as quite easy relative to other firms with less knowledge or skill. While problem complexity may be measured empirically, problem complexity as perceived by the firm is in the eye of the beholder. Thus the relationship between between problem novelty, perceived or real, and problem complexity, perceived or real, is a critical factor in how firms activate and control projects.

### *Environment Complexity*

It is one thing to do a project when the outside world is static. It is quite another to do a project when the external environment is undergoing rapid change. Just as it is easy to type on a mobile phone when one is seated, it is harder to do so on a bumpy train ride when the external motion of the train requires extra concentration and new forms of muscle contractions. Complex environments have features in them — customers, competitors, suppliers, partners, regulations — that can be highly changing or highly unknown. For example, for projects in countries with more informal local governments, regulatory requirements that may need to be met may be unknown at first and changing over time. Supply chains projects in quickly emerging markets may have new entrants (partners of competitors) showing up in the middle of a project raising project difficulty.

Environments with high complexity are dynamic with significant on-going industry, regulatory or market changes, are ones where the firm cannot easily discern who the customers, competitors, suppliers, partners are and what local rules might be, or are in fast-moving environments where changes are occurring quickly. Environments that are low in complexity do not have significant industry changes, for which all the competitors, partners and customers are known or easily knowable, where the regulatory environment has been stable and for which the time-intervals of changes are sufficiently lengthy or well within the firm's ability to handle. Complex external environments tend to move very quickly, usually with short time-frames, for which a project structure might be more suited than the current firm structure.

### *Organizational Complexity*

Just as the external environment may be complex, so too can the internal environment within the firm. When a project is activated, leaders will often take into account the complexity or stability of the firm's organizational setting in deciding how to activate the project. The level of resources activated internally and externally will be moderated by this perceived or actual organizational complexity.

Organizational complexity includes can include things like management stability, financial stability, project leader and project team stability, overall organizational structure stability, level of management and team commitment to project goals, abilities for project team members to effectively solve problems socially, level of agreement or conflict within the firm hierarchy and the level and stability of access to resources and capabilities. Firms with higher levels of organizational complexity are likely to activate a project rather than use the current firm structure.

Firms with low domain knowledge or skill or that are experiencing high levels of organizational complexity may undertake projects that result in significant changes to project scope, timeframes and deliverables. While problem complexity, especially technical and environmental complexity, can add scope to a project causing control difficulties, more often than not organizational complexity contributes to project failure (Henderson, 2006; Nasir & Sahibuddin, 2011; Montequin, et al., 2018).

### Novelty, Complexity and Project Activation and Control

Firms are likely to activate projects when any combination of problem novelty, or problem, environmental, and organizational complexity is perceived by the firm as high enough to warrant an alternate structure. Since many firms subjectively evaluate complexity, the decision to activate a project or not as well as the types of interventions taken within a project once started will be modulated by the firms perception of the overall complexity and problem novelty, not just driven by an externally validated measure or determination of complexity or novelty.

Project activation and control follow the same processes for both type 1 and type 2 projects. Projects that effect a change without much alteration in the firm's stock of knowledge, its processes or any other form of organizational capital (know how) can be explained similar to firms that attempt to rewire firm processes and create new stocks of firm knowledge. Projects will still be activated when the firm wishes to gain access to disparate resources and to optionally incorporate new knowledge in the endeavor. What matters is not the learning goal (add to firm stock of knowledge or not) or the local for the change (delivering change inside or outside the firm), but the need to activate and coordinate distributed and normally isolated capabilities without upsetting the overall firm structure.

These factors that describe the activation of a project can also be used to examine project failure. Projects live somewhere between pure order and pure chaos. As problem novelty and complexity rises in each of these dimensions, firms are more likely to use a project structure, but should complexity or novelty rise too high, projects themselves are increasingly at risk. Firms will tend to intervene and control projects when novelty and complexity are perceived as rising too high. Because of the interactions between the complexity factors and firm perceptions, this means that projects can fail at the lower or higher levels of novelty and complexity. Just as in human working memory, depending on the prior knowledge of the person, the complexity and ambiguity framing of the problem affects human problem solving. Some problems are solved with little effort whereas some problems are unsolvable at any level of effort. The multiple interactions of the various factors make specific project predictions and conclusions difficult and that are frequently at odds with each other. If the combinations of factors are not considered carefully, explanations of project success or failure are likely to be contradictory.

This four-factor framing of project activation and project failure is largely consistent with the research regarding complexity and projects (San Cristobal, et al., 2018, Cooke-Davies, 2011, He et al., 2015). However, firms and project leaders frequently under-explore the organizational and especially the difficult social problem solving dynamics within projects and often lump these factors into the category of firm politics. Many project managers struggle with this human dimension. Two forms of cognition are at play within projects: individual problem solving abilities and team-based social problem solving abilities. At the connection between these two worlds likely lurks a whole host of troubles and insights into many difficult project questions including but not at all limited to why do projects seem to be bounded by size? Why are larger projects more difficult for firms? How does project modularization affect the complexity of social interactions needed? Do limits in human cognition contribute to limiting the size of projects? If so, how? What are ways to avoid letting office politics and firm culture affect projects? Looking at how humans go through decision-making processes may shed some additional light on these questions.

## Project Decision Making Processes

Insights gleaned from research into human problem solving processes are remarkably valuable for gaining insights into projects. Since projects tap into ancient human social capabilities, human beings tend to work in projects in repeatable ways. As a result, the mechanics of their behavior exhibit repeatable patterns. At the level of the individual, cognitive psychologists have described repeatable thought processes that go into problem solving as falling into two distinct stages: differentiation and consolidation. While research into working memory have described processes in different ways and at different levels, from the neurological to the functional, a track of research called differentiation and consolidation (DiffCon) theory (Svenson, 1998, 2003) has relevance to projects. Just on the face of it, individual working memory must connect and human social problem solving and group decision that involving many minds. These individual decision

processes interact with and are aggregated at the group level, thus individual cognitive and emotional processes can serve as a useful way of describing group processes within projects. With this assumption and with DiffCon theory in hand, decision processes within projects can also be described as being divided into the same two categories: a) differentiation which are processes that generate decision alternatives for selection and b) consolidation, which are processes that integrate the decision into the decision-maker's future actions knowing that the future is uncertain. Decisions have to withstand the "roughness of the future" and hence undergo a series of rational and sometimes irrational processes by the decision-maker pre- and post-decision (Svenson, 1998).

## Differentiation

In DiffCon theory, decisions can be quick involving little to no working memory or be more deliberate and engage working memory heavily. DiffCon theory accepts these two types of decisions and treats them as operating on a continuum, so it is similar to theories that explain how these fast and slow decisions are made by separate brain networks (dual-processing theories of decision-making, see Evans, Stanovich, 2013; Kahneman, 2013). Within projects, teams make countless decisions that pass through not just individual minds, but many minds with most, but not all of the salient decisions being effortful. The processes and decision rules each team member uses for these effortful decisions become the basis for how project process play out. In good projects, team members make good decisions individually and in concert with each other, ensuring the project achieves the best balance between globally optimal designs and effective use of time and effort. In difficult projects, teams struggle to converge on design choices and undergo oscillations based on feedback loops between teams that cause unnecessary rework.

In anticipation of the consolidation phase, the individual generates a set of decision alternatives and then goes through different processes of eliminating alternatives until a promising candidate and a close competitor are selected for further evaluation. Once an alternative is selected, commitment to the choice sets in and the decision needs to be defended against possible threatening factors. The differentiation phase has a number of rules that people can use to comb through the alternatives. Depending on the rules used and the distance in terms of attractiveness between the top two or three alternatives, commitment to the decision can vary. The greater the commitment to the decision, the greater the level of effort in differentiation, thus problems judged more important will receive more effort. The decision maker "must find or create an alternative that is *sufficiently superior* to its competitor(s)" (Svenson, 2003), but modulated by the effort invested.

Differentiation processes have distinct phases including, identification of alternatives (discussed above), use of markers, goal elicitation, screening and editing. Markers serve as initial salient aspects of a project that helps decision makers start evaluating alternatives. For example, a data integration architect working on an information technology project may be tasked with working out the best approach for moving data from one system to another and may be initially drawn to the analysis by a highly salient feature between two alternatives. In this hypothetical case, one alternative uses a large, batch-like process, the other uses an incremental, real-time approach. In this example, the architect may start the analysis on the trade-offs in effort between the batch-like approach versus the real-time approach. Markers can be related to the goals in place for the project and may bias decisions towards or away from the marker. For example if a specific goal for this project is that other teams designing integration points are planning on using the real-time approach to align with a common data integration strategy, this architect may draw her attention to this specific feature. In the editing phase of the decision process, the architect will start to arrange the different aspects of the different design choices to begin evaluation. In this example, the architect may decide to use a more formal matrix evaluation of each feature between the alternatives instead of using a more intuitive and holistic decision approach that is quicker and based on strong preference or affective attachment to one of the approaches. Screening occurs when the decision maker eliminates some choices early in the process. In this example, the architect may have tossed out a method integration even before getting to a more elaborate comparison of the design alternatives. At some point in the decision making process, the decision maker, in this case our architect, settles on an approach and commits to a decision. Differentiation processes in one mind may be complex. In a project involving many minds and many tacit and explicit decision tools with fragmented communication of insight coordination of decisions, differentiation processes in a project can be wildly complex, if not erratic.

## Consolidation

Decisions are not static once made. Individuals making decisions are still processing the decision both rationally and emotionally. The decision maker may feel the loss of alternatives after making the decision as unsettling and may be regretting some negative consequences that are part of the decision, creating a form of dissonance or kind of buyer's remorse. The decision maker will begin to monitor the decision so the actual outcome is close to the desired one and if

possible, change the post-decision situation so that it is highly favorable and restructure the representation of the decision problem to provide additional support for the decision (Svenson, 2003).

IT governance monitoring a project is an example of post-decision consolidation whereby not just one individual, but many may undergo these consolidation processes of revising in their minds the shape of the problem after the decision, monitoring the decision to ensure it is favorable and altering the post-decision situation with additional decisions to provide support for the main decision. For projects, this consolidation of a decision can be useful in altering thoughts and actions of project team members to keep the project on track, but it can also lead to a sort of sunk-cost bias whereby project team members, and more importantly, key decision-makers, continue to attempt additional post-decision consolidation with follow-on decisions that keep the project team committed to the same but errant path.

Since projects have myriads of these kinds of decisions, emotion and affect become increasingly important in both differentiation and consolidation phases. Projects with teams that have difficulty in making decisions, such as not making timely ones or repeatedly making decisions that may optimize one small part of the overall project but cause difficulty for a much larger part of the project, can be traced back to difficulties in the differentiation processes. Differentiation processes can be short-circuited by staff making a more intuitive or holistic judgement with strong emotions driving them. Projects that have suffered through difficult differentiation processes may also suffer from irrational post-consolidation support for the decisions. These differentiation and consolidation processes take form in daily and usually informal conversations between different combinations of project team members and governance groups surrounding the project. These discussions are held between team members of different power and skill relationships with considerable room for influence based on affect and emotion rather than clear reasoning processes. Most project managers are not trained or highly skilled in ferreting out which of these conversations represent errors in differentiation or consolidation processes. Emotion, bias and errors in decisions are very much a part of project life and are likely the primary, not secondary contributors to project difficulties, yet project managers and organizational leaders receive little training in how to detect, diagnose and treat these maladies.

Projects are rife with these asymmetrical conversations between people that cause teams to periodically struggle. Teams fear being subverted, becoming unimportant or losing power relationships. This causes biases in their differentiation and consolidation processes. Normally, the particular decision-making approach a firm uses on projects gets lumped into a catch-all basket called culture that may conveniently let teams place blame on a murky label (an example of a post-decision consolidation process), but does not shed light on the precise nature of the difficulty or the steps needed to place the project on track. Change management in practice also suffers from an excessive focus on rationality and broader, programmatic communication strategies rather than addressing the subtler and difficult personal struggles within projects and the myriad of group decision biases. Projects tend to suffer from a lack of a rich vocabulary and framework for analyzing and measuring decision processes. By recasting a project as firm working memory, the decision processes within project then demand a fresh look and a deeper treatment. DiffCon theory provides some useful concepts.

## Design Oscillations

The intricacies and complexities of the rational and irrational individual decision processes play out like a symphony of cicadas on a summer evening. These decisions are made by individuals in coordination with each other with a wave-like and cyclic propagation pattern. Decisions made in one group get communicated out, causing adjustment by other groups with unknown impacts and communication flows until a feedback loop to the original decision-making group causes another alteration in their designs and another iteration. Excessive design oscillations, often called “spinning your wheels,” is the bane of complex project management. Because of the many information flows affecting decisions facilitated by this complex formal and informal human network, project design decisions can iterate, oscillate, diverge and converge.

Projects managers and team members, especially those in IT projects, are familiar with design iterations. Agile methodologies evolved to embrace iteration as a virtue not a vice. In each iteration, goals are established, albeit more local goals rather than goals addressing the larger project, and the teams conduct a short burst of design decisions and implementation activity to optimize their effort and delivery for the local team. Agile methods also turn abstract designs into concrete reality, enriching the flow of information to project team members. On large scale projects, multiple iterations like this need to be coordinated with local optimization (fitness and cost) balanced against global optimization (fitness and cost). Within an agile methodology, design iterations can be considered good since they are a way of uncovering knowledge in a higher quality, quicker and more incremental way, facilitating team learning. In a large project, the trick is in communicating relevant knowledge from each design iteration to other teams.

Design oscillations are the result of new information being communicated to design teams that can cause rework. Again, since knowledge about how to complete a project is incrementally "consumed" by team members, design oscillations are a natural metabolic byproduct of knowledge foraging behavior. Design oscillations represent the key engine of the project metabolism (Kellen, 2019a). The problem lies in the timing of and team cooperation in synchronization of efforts related to design oscillations. Thus design oscillations can be good or they can be bad. In general, early design oscillations with cooperating teams balancing local needs and optimums with global needs and optimums are a healthy sign of a project focusing and coordinating resources and learning.

Design and resulting decision oscillations that continue too long can lead to divergence rather than convergence. If designs converge acceptably within the overall project timeframe, the project has a higher chance of successful completion. When designs oscillate and diverge for too long, a project may fail to converge on the right set of design decisions leading to a higher chance the firm may abandon the project or the project may have an outcome that is woefully short of expectations. Unsurprisingly a significant preoccupation for project management is in avoiding fateful decision oscillations.

Network simulations of these dynamics reveals translatable management guidance for projects (Mim, et al., 2003; Braha & Bar-Yam, 2007). Larger projects have a greater chance for not converging in solutions. Teams can manage half the number of inflows of information than outflows, creating a "bounded rationality" limit on information absorption that can affect decision dynamics. Limiting project size can help and highly modularizing project components can accomplish limiting project size by sealing off in semi-isolation parts of the project, essentially creating a flotilla of mini-projects. Design decisions and preliminary designs before decisions have been reached should be broadcast widely and frequently. This creates a necessary communication overhead for which project management offices are typically designed to accommodate. If project teams can reduce interdependencies between project teams, it has the effect of thinning the project and enhancing design convergence. The project behaves as if it were a smaller project. Chunking (modularizing, but linking in larger groupings), and improving cooperation between teams on designs helps as well. Project management and enterprise architecture become key resources in orchestrating the modularity and enabling communication across the project teams.

What is most interesting in these simulations is that these design oscillation and information turbulence complexities arise out of the network properties of the project itself even without considering the myriad of rational and irrational variations in personal and team decision making. The order by which teams work through tasks matters greatly and can excessively perturbate a project. Just treating the project as a complex information network strongly suggests that the network dynamic properties are critical aspects for project management to control. Projects serve a similar function that human working memory does in managing the timing and coordination of networks of distributed resources. The network properties of the project information flows in and of themselves are complex and critically linked to project success.

## Social Cognition, Emotion and Problem Solving

Social problem solving can be considered distinct from problem solving without a social context. Solving a difficult math puzzle unrelated to one's personal social network is quite different from solving a difficult social problem where one has to envision the states of other people and build appropriate plans of action. Based on the social brain hypothesis (Dunbar, 1998) Homo sapiens brain size most likely grew in size and complexity in order to accommodate more complex social networks and collaborations. The increase social cognition for humans proved successful as the complex collaborations between humans has enabled the exponential population growth and the economic benefits of human innovation.

Just as humans are limited in working memory to about four independent items or chunks, humans are also limited in social cognition to about four levels of "mentalizing" reasoning. Briefly, mentalizing is the process by which one imagines what someone else is thinking. When a project manager starts to opine about what a specific resource on a project is thinking, the project manager is mentalizing about just one relationship or level. When a project manager is wondering what an executive sponsor might be thinking about what a technical resource is doing, the project manager is engaging in mentalizing two levels of relationships.

And just like working memory capacity, human beings are limited in their mentalizing and social cognitive skills. Some of us are very good about mentalizing four or maybe five levels whereas others of us are not. Some of us are very good at incorporating more complex judgements about future goals while undertaking social decisions, and especially inhibiting

incorrect urges or intuitions based on emotional responses. Also, higher order mentalizing tasks are cognitively demanding and human social problem skills are most likely undergirded by neurological processes that while distinct from working memory also overlap portions of working memory (Lewis, et al., 2017). More research is needed to establish the linkages between working memory processes and social problem solving processes.

Personality and affectivity explains a significant portion of social problem solving ability (D'Zurilla, et al., 2011). In this line of research, problem solving has two components, problem orientation and problem solving style. Positive problem orientation is a general disposition to consider a problem a challenge, a belief that the problem is solvable, and that one has the ability to solve it. Negative problem orientation individuals perceive problems as a personal threat to well-being, doubt that one can solve the problem, and get easily frustrated and upset when confronted with difficult problems. The three problem solving styles that people employe are rational, impulsive/careless and avoidance (Chang, et al., 2004). Maintaining a positive problem orientation and using a rational problem solving style, as expected, are associated project success.

These social problem solving dimensions interact with classic personality dimensions psychology researchers have studied for decades. These are neuroticism, extraversion, openness, agreeableness and conscientiousness. Each of these individual personality traits correlate highly with the five social problem solving dimensions and the most consistent predictor of social problem solving is conscientiousness. These measurement scales for social problem solving have been applied in counseling and mental health contexts, as expected, but to-date, research examining social problem solving abilities in projects is limited. More research has explored the five factor model of personality mentioned above and how project manager characteristics affect project success (Wang, 2009) and a richer track of research has examined emotional, managerial and leadership competencies and project success (see Geoghegan, Dulewicz, 2008; Muller & Turner, 2007 for examples).

Affect (emotion), can interact with human working in one of three ways. Affect can modulate working memory (often by creating a bias), can be regulated by working memory (as in human working memory controlling the role of affect in problem solving) and can use working memory to process different contemplations of emotions. The role that affect plays as individuals age changes over time, with older employees able to maintain affective working memory performance despite declines in cognitive working memory. Affective working memory in humans is a domain-specific subsystem for maintaining feelings. (Mikels, et al., 2019).

The complexity of the underlying human cognitive architecture hinted at here and the distribution of different social problem solving skills, orientation and personality traits across teams presents project management with a significant challenge. Team-based abstract problem solving skills may only be partially separable from affect and social problem solving skills, leading project managers to confound the two or fail to detect them sufficiently. Individuals differ greatly in these various skills and leaders place heterogenous values on these skills causing them to be placed haphazardly or in biased ways within the project team and the firm. Collectively, social problem solving skill heterogeneity and placement may be a significant factor in the successful control of projects. While this is intuitively felt by project managers and project participants and occupies plenty of casual discussion among team members, rarely do projects systematize improvement efforts using these theoretical frames.

Based on the descriptions of mentalizing, emotional working memory and social problem solving, could a metaphorically similar subsystem for projects be needed as well? The most relevant structure for this today lies in the domain of change management, and more specifically, the role that change management practitioners play in maintaining and moderating individual and group emotional responses on projects and regulation of decisions. Projects may require an architectural and organizational design lens for the affective and social dimension.

Research on projects as repeatedly, but not conclusively, found that larger projects tend to fail more so (Sauer, et al., 2007). Could the bounded rationality limitations in human working memory, mentalizing, emotional working memory, social network size (Dunbar limit) and social problem solving explain the limit on project size? Are some projects just too big for team minds? Could the disparate arrangements and use of these skills, normally not addressed by leaders during project activation or control, explain variations in project performance?

Human working memory not only solves abstract problems but it also plays a role in mentalizing, emotional regulation and social cognition. Working memory interacts with affective and personality dimensions in ways that can bias judgements and decisions. Thinking of projects as firm working memory opens up these avenues of inquiry. The project management

woes of sub-optimal designs, biased decisions and failure to converge on an appropriate solution will appear often as mild symptoms early in a project before their fateful impact is felt and assessed later in the project, if at all. Post-decision consolidation processes can often create a kind of 'self-sealing' which recruits reasons to decisions and can prevent the firm from adequately probing the project for decisions and coordination weaknesses along these individual and social cognitive lines. If the project is akin to working memory, finding network or system solutions to emotional regulation and social problem solving should significantly improve project performance.

## Implications for Project Managers and Leaders

Because the project aggregates individual and social problem solving activities, project behavior recapitulates individual behavior. This is not surprising since projects are a collection of tasks performed by individuals. Considering a project as firm working memory helps place many project dysfunctions into one framework. The project-as-working-memory dysfunctions can be concisely described as falling within four domains:

- Project-firm structure**.** A structurally malformed or a dysfunctional project hierarchy or firm hierarchy resulting in faulty communication and control dynamics that can lead to design oscillations that fail to converge on an appropriate and cost-effective solutions.
- Complexity. Excessive complexity within the project problem and outside the project in the firm and external environment. How projects interact with their environment affects project outcomes.
- Human biases. Biases in decision-making and judgement before, during and after a project.
- Human variability. Individual differences between people in personality traits and in problem solving abilities, social, emotional or otherwise.

Borrowing mental models from working memory and social cognition frameworks, project management effort can begin to form some helpful practices that address these difficulties. Project managers can consider a series of recommendations within their project plans including the following:

**Assess project problem complexity and ensure a project match for firm skill and context**. Determining what makes for a project too large or too complex is itself a complex problem that involves assessing firm prior knowledge and skill, problem complexity, problem novelty, environment complexity and organization complexity. It doesn't take much experience to know that there is a significant difference between a highly capable firm taking on an easy problem in a stable internal and external context than a less capable firm taking on a very hard problem in a state of internal and external flux. It does take experience, knowledge and skill to know how to assess project pre-conditions. Properly measuring these dimensions of project complexity matters.

**Embrace and prepare for design oscillations.** Because of project teams' bounded intellectual and social reasoning and because of the complex social networks inherit in human organizational life, the fundamental design uncertainty in projects will continually be problematic. Problems within projects are complex and it takes teams time and several feedback cycles to master the technical complexity within the project. Planning for and managing the design oscillations that occur and that represent effective or ineffective team learning are top project management concerns. Projects can be emotionally charged at times causing decision difficulties. The social learning dynamics brought about by a complex network proves far more vexing to project managers and more critical to project success than modeling the technical dependencies and linkages in the artifacts and design documents within the project.

**Expect and correct for biases.** Based on human neurology and psychology, people within projects will have numerous biases in reasoning and judgments created by both cognitive limits and the various affective/emotional contexts, which usually become more pronounced under highly uncertain conditions. Project sponsors and firm leaders are likely to engage in errant post-decision consolidation behavior including revisionist history, motivated reasoning that recruits reasons to support failed project decisions, sunk-cost bias, and defensive reasoning that tries to cover up problems that then prevents proper firm learning about how to handle the current and future projects better. Project leaders and project managers need to develop and deploy project and individual de-biasing techniques and ways of addressing the interplay between affect and logic that roils projects.

**Reduce problem novelty and project complexities through preparatory learning.** Leaders and project managers need to developing organizational capabilities ahead of major projects and continually once the project is started, especially if the firm is managing a portfolio of projects, as most do. The sequencing of organizational learning can make the difference

between project success and failure. Merely importing knowledge and skill from outside firms, just-in-time, into the project may be insufficient. Leaders need to carefully think about what knowledge and skill is critical to develop within the firm. Often this analysis leads to developing de-biasing, communication, continuous improvement, change management, enterprise architecture and project management skills internally as part of an ongoing project management capability. Also, establishing the order of precedence in a large complex project portfolio that allows incremental absorption of "chunked" knowledge and full integration into the firm's stock of capabilities can help prepare the firm more easily handle complex projects ahead. "Pre-habbing" the firm can help the firm master the changes the project will entail.

**Build a project structure to facilitate optimal knowledge flow and team effort.** Project leaders and managers need to pay close attention to structuring the teams within projects taking into account the advantages and disadvantages of hierarchical and network organizational structure. The project structure has to be able to activate and coordinate distributed resources. Problem complexity can be reduced through modularization in which breaking down large units of the project into smaller chunks can take advantage of local hierarchies for efficient knowledge access. Project leaders can control project throughput by using parallelism wherever possible. This allows work to be spread across teams for semi-isolated execution. In some cases, it may require setting up "barriers" or forms of lateral inhibition between parallel teams where feedback from one team to another is suppressed or feedback from one team diminishes or down-regulates another team's output or demand for attention. Complex networks in chemistry and in neurology have this notion of negative or inhibitory feedback loops as a deep property to ensure coordination of potentially conflicting information and action not suitable the goals at hand. While competition does exist between teams on project, most of this lateral inhibition, if it occurs, occurs unregulated by the project management team. Project leaders should also ensure the right flow of lateral communication across project modules occurs early and often and should carefully sequence activities especially from a learning perspective. Some activities done early by some teams may prepare those teams for work later in the project. Project management, like working memory, needs to orchestrate the timing of different learnings and different actions and always with an eye for applying learnings quickly.

**Measure human behavior to detect and predict project lifecycle issues.** These social problem solving dynamics represent the project's metabolism and creates the famous S-shaped curve to project growth. Teams of humans "consume" project requirements or knowledge bundles in predictable ways and given project scope and need for action bounded by time and budget, consume those bundles in a constrained environment. When appropriately measured, these social processes and the resulting S-shaped growth pattern projects take makes them predicable through statistical inference. Measuring project growth and requirements and task volatility can shed insights into design oscillations and estimated completion without knowing the innards of the oscillation causes or technical linkages within the project problem.

**Expand beyond or de-emphasize the technical and causal modeling of projects.** Causal logic embedded in project plans does not usually take into account the complex and stochastic activities within technical feedback loops. These detailed project plans sometimes fail despite a robust understanding of the technical aspects of a project. The design oscillations can overrun the best of project plans. By itself, causal logic within work breakdown structures, critical path considerations and resource leveling and allocation will be insufficient for managing complex projects. Moreover, the changes within these causal linkages originate from the social and individual decision processes throughout the project teams. The effort in recording, analyzing and managing these technical linkages, which change frequently, is often quite large. Projects that rely more on social behavioral data analysis with simple lists of tasks without any hierarchical, relational or technical modeling can often perform better than firms with more elaborate work breakdown structures, dependencies and highly modeled human resource constraints, especially if project instrumentation adequately captures and measures the social dynamics. These more technically "lightly modeled" projects can still activate and coordinate distributed resources with less central project management office overhead.

The project-as-firm-working-memory approach also suggest some promising lines of additional inquiry, some of which include:

- What multi-unit communities of collaborators lurk hidden in the firm and project structure that may be helping or hindering success? Can multi-level social network analysis methods help?
- How do design oscillations show up in human behavior? How do we measure them? How do we determine positive from negative design oscillations? Is timing of an oscillation the only way to measure this or are there other easily gotten measures for positive or negative design oscillations?
- Are there case studies of firms that have utilized effective project pre-condition preparation techniques to reduce problem novelty? How would this be adequately measured?

- Behavioral data might be more helpful than typical survey data used in project management research. What is the gap in current research between how project participants respond to research and survey designs versus the underlying processes at work? Just as introspection in human subjects on their own cognitive processes can be unreliable, so too can retrospectives on project success and failure. Do we need more studies grounded in actual behavioral data?
- Many studies related to projects and complexity rely on computer simulations for gaining insights. Do real-world projects exhibit the same dynamics? Can real projects be instrumented to replicate these simulations?
- How do consolidation biases affect project announcements, post-project recollections and inhibition of firm learning? How much do these post-consolidation processes interfere with firm learning about managing projects or managing the change the project produced? What impact does this have on firm performance?
- What education do project governance members need regarding this approach to project management which runs counter to conventional thoughts? How does the approach specified here affect project governance decision-making processes?
- What specifically are the connections between individual working memory, social problem solving and project performance? How do these affect limits in project size and growth?
- What are new structures for project teams that are based on better assessment of team player cognitive and social problem solving skills? What practical and fairness implications does such an approach mean for constituting project teams?
- Should agile be the dominant model for project management? The project-as-firm-working-memory model strongly suggests that projects need to be broken down into modules and within modules, further decomposition and iteration is needed to enable a scaffolding of learning whereby early learnings enable future success. Is a modified agile approach effective for very large projects?

Over time, these questions and many more can be elucidated by others. For now, one major implication for the project-as-working-memory framework cannot go unnoticed and it relates to the selection, training and development of project managers and project leaders. Firms can select and develop these leaders based on different criteria than is typically done. Criteria could include the candidate's ability to reason about project complexity and organizational dynamics, their social problem solving ability, their knowledge regarding structuring the project teams to ensure optimal design oscillations and solution convergence, ability to detect team emotional and social cognition difficulties, and perhaps more importantly, an evaluation of personality traits for effectively absorbing and managing in highly ambiguous or uncertain environments. One large question goes begging: Is project management certification as it stands today with its nearly exclusive focus on the technical skills and deterministic, causal reasoning mindset sufficient? In this cacophony of social and individual cognitive complexity that runs projects aground, does project management certification still matter?

## Summary

This conceptualization of the project draws inspiration from the complexity sciences, the dynamic capabilities approach to firm competitiveness, theories of working memory and social cognition and depictions of temporary organizations (Lundin and Soderholm, 1995, Turner & Muller, 2003). These frameworks bring needed focus on this often irrational and uncertain underbelly of project life. In practice, most firms elide over the need to address these bounded rationality and unpredictable adverse dynamics that lie in the heart of all projects. Firms cannot manage what they cannot see. Most, if not all of the non-rational aspects in temporary organizations can be placed within working memory and social problem solving theoretical frames presented here.

The orthogonal project structure which orchestrates communication, isolation and collaboration of distributed resources in a relatively non-threatening way, is a consequence of the complex social and information network structure that connects various firm hierarchical structures. To manage temporary, complex endeavors, human beings create complex social networks. A theory of projects and project management that utilizes the cognitive and complexity sciences may be more fruitful than the dominant approach in use today. By conceptualizing the project as an ancient human social structure designed to exchange information and coordinate distributed capabilities to solve complex problems without threatening the cohesion and stability of the dominant hierarchy, we gain two significant advantages.

First, the work in keeping track of the all the causal linkages in a project's technical problem can be diminished or outright suppressed, saving considerable project management and team effort without sacrificing control. This time can be reallocated to project activities that can better identify and control the social and cognitive dysfunctions that arise across

the distributed resources. For project managers, the causal and technical linkages within the design oscillations matters less that knowing a design oscillation is occurring, if the oscillation is timed appropriately and if the social behavior suggests the oscillation is shifting to converging on a solution. Technical leaders and project managers can separate their concerns more clearly, creating a curious form of semi-isolation between the project management discipline and the enterprise architecture and design disciplines. Project managers don't need to chase causal ghosts while chasing flighty humans. Enterprise architects can spend more time utilizing reference architectures and designing how the technical pieces of the project fit together, and together with organizational design and project management experts, they can design the parallel, semi-isolated but coordinated network work structures needed to implement the technical solution. When it comes to successful projects, architecture of people is as important as architecture of technical components.

Second, by instrumenting the project to better capture this dynamic social complexity, we can infer more about the behavior and future of a project than with the causal and deterministic systems today. Projects, based on innate human sociality, will reliably reproduce themselves, with similar human behaviors at work. This opens up the project to a repeatable behavioral measurement approach. Rather than devise and continually revise an elaborate set of dependencies that evade their ken, project managers can observe and measure the project's social behavior and from that data, diagnose the critical dysfunctions afflicting projects. Inference gained from continually observing human project behavior can identify maladies quickly without requiring domain-specific, deterministic knowledge from the project management teams. Timely, behavioral inference can trump ephemeral, illusionary causality.

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