Project management between will and representation

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ABSTRACT

This paper challenges some deep-rooted assumptions of project management. Inspired by the work of the German philosopher Arthur Schopenhauer, it calls for looking at projects through two complementary lenses: one that accounts for cognitive and representational aspects and one that accounts for material and volitional aspects. Understanding the many ways in which these aspects transpire and interact in projects sheds new light on project organizations, as imperfect and fragile representations that chase a shifting nexus of intractable human, social, technical and material processes. This, in turn, can bring a new grasp of notions such as value, knowledge, complexity and risk.

Key words: complexity, knowledge, value, goals, materiality, planning, risk, governance

Introduction

From building transportation infrastructures such as bridges and airports to designing airplanes and dispatching exploration missions in space, from creating information and communication systems to editing videogames and other software products, and from developing new medical drugs to organizing vaccination programs, complex projects are an essential part of advanced economies and societies. Yet many complex projects are not implemented fully, or end half-way through execution, or else are plagued by conflicts, litigations and scandals, by significant cost and schedule overruns, by widespread dissatisfaction with their activities, final form, functions and benefits, and sometimes by accidents with catastrophic consequences for people, nature and societies. The project management discipline seized upon various perspectives and developed new approaches attempting to explain and address deviations from what it considers the normal course of a project. These attempts have recently produced a deep reconceptualization of project

processes, knowledge production, stakeholder management, contractual design, risk management, as well as organizational governance, flexibility and reliability.

One problem with these attempts is their low integration; each of them relies on different assumptions and they often produce recommendations that contradict each other and the basic tenets of project management. For example, some recommended contractual designs create problems with knowledge production and organizational flexibility, while others hamper cost control and organizational governance (Floricel & Miller, 2001). Researchers have tried various ways of bringing these approaches to a common denominator, by conceptualizing projects as organizations in their own right or, more recently, by adopting a practice perspective on project management. But these integration efforts are themselves plagued by heterogeneous assumptions and methodological foci (Floricel, Bonneau, Aubry & Sergi, 2014), producing polyphony rather than dialogue and slowing down theory development.

This essay attempts to provide a common ground for the efforts to re-conceptualize project management by seeking inspiration in the philosophy of Arthur Schopenhauer (1821/1966) in order to reassess some deep seated assumptions of the discipline. In essence, traditional assumptions depict project management as using knowledge about user needs, natural environments, technical objects and human behavior in order to produce, through rational selection, decision, problem-solving and optimization processes, a series of prospective representations of project form (architectural and design depictions, technical drawings, site maps, production flowcharts etc.), resources and activities (goals, development processes, Gantt charts, budgets, risk matrices etc.), and organization (hierarchical charts, contracts, rules and procedures etc.). These representations then become a teleological engine (Van de Ven & Poole,

1995) that drives implementation activities. Managing projects amounts to monitoring and correcting deviations from these prospective representations (Floricel, Banik & Piperca, 2013).

Our inquiry originated in the incongruence we felt between this depiction and the reality we perceived while studying complex projects, characterized by multiple iterations, deceptive embellishments or even Machiavellian manipulations of representations, as well as conflicts, heated debates and tentative commitments between participants, that together with events that appeared as unexpected in light of participants' representations produced endless changes in project form, organization and activities. These observations suggested us that representations do not drive projects; they are merely a temporary truce under pressure from a heterogeneous and constantly shifting nexus of interests and forces. Following Schopenhauer, we term this nexus 'will' and argue that current thinking in project management misinterprets its nature and underestimates its role. Inspired again by Schopenhauer, we also argue that representations are not mirror depictions of surrounding realities and future projects. Instead they are constructed at various levels, including in manipulative ways, and are used strategically to advance interests and activities. This enables us to argue that project management is the process of bringing and keeping together numerous heterogeneous and evolving strands of 'will' and 'representation', and attempting to master the wildly emergent, rather than teleological, nature of this process.

We hope that by clarifying the complementary categories of 'will' and 'representation' in relation to issues encountered in complex projects, we provide an explicit worldview and parsimonious set of fundamental concepts around which project management scholars could articulate their theorizing efforts. The specific contribution we expect is to help integrate a series of fundamental concerns of project management researchers, starting with the understanding of complexity and processes (Cooke-Davies, Cicmil, Crawford & Richardson, 2007; Whitty &

Maylor, 2009), and ending with the recent interest in practice and actor-networks, including the renewed interest in the role of materiality and the calls for a symmetric treatment of human and nonhuman 'actors' (Latour, 1991; Barad, 2003; Orlikowski, 2007). In turn, this will hopefully enable the integration of various applied and practical developments to which we alluded above.

We begin this conceptual development by introducing, in the next section, the concepts of will and representation as reflected in Schopenhauer's philosophical works, and by showing how these concepts can be seen as extending, directly or indirectly, into some current thinking in organization theory and the project management field. The last section of the paper discusses the implications for project management research and practice.

Understanding 'will' and 'representation'

In 1818, German philosopher Arthur Schopenhauer published a book whose title is most often translated in English as "The World as Will and Representation" (Schopenhauer, 1966). The book sought to answer questions about our relation to the world that went back at least to Plato and Aristotle. In particular, Schopenhauer argued that our subjective relation to the world is, on the one hand, a 'representation' constructed by our cognitive faculties, and, on the other hand, a 'will' that works through our inner desires and sentiments. Rather than proposing a new dualism, he sees these two aspects as intertwined. In fact, the main reason we return almost 200 years back is that subsequent philosophical works emphasized one aspect at the expense of the other. On the one hand, phenomenology (Husserl, 1913/1931; Heidegger, 1927/1962) and logical empiricism (Bunge, 1996) seem equally concerned with the 'representation' side of being in the world, while, on the other hand, Nietzsche, existentialists and even materialists appear to

emphasize ‘will,’ be it as freedom or as necessity. We sought a perspective that balances these two aspects because we came to the conclusion that they are inextricably linked and play an equal role in projects. With such a perspective we hope to overcome a certain disconnect between in these aspects in the project management field. While the official project management discourse, backed by literatures rooted in decision theory, economics and optimization (Winch 1989; Chapman & Ward, 1996; Brucker et al., 1999), emphasizes the rational construction and embodiment of systemic and structural representations, the informal, everyday discourse of managers, with some support in the literature on the “human side of project management” (House, 1988), often strays into discussing volitional and emotional aspects and the interpersonal efforts needed to keep the project alive and enable effective action.

Schopenhauer’s ideas suggest not just a path towards restoring the balance and enabling the integration of these aspects, but also a parsimonious set of distinctions, which, with proper interpretation and actualization, could provide a conceptual kernel for rethinking the nature of project management. We begin by discussing the ‘representation’ aspect, before clarifying the particular meaning of the term ‘will’. The section ends with a discussion of the interaction between ‘will’ and ‘representation’. In each subsection, we outline recent developments that echo Schopenhauer’s views as well as implications for the understanding of project management.

Representation

Following Kant, Schopenhauer argues that our representation of the world presupposes certain *a priori* cognitive faculties, the most basic of which are the capacities to represent time, space and causality. Because of this, while admitting that there is a reality out there (a “thing” in itself) and that representations are an immediate correlate of this reality, Schopenhauer argues that the

constructed nature of representations precludes us from knowing the true nature of this reality based on our perceptual sensations, or on our abstract ideas. In particular, we cannot assume that this reality has the same properties of space, time and causality inherent in our representations of the world as a priori forms of our sensibility. The constructed nature of representation concerns the immediate perception of the world, but even more so other representations, in particular abstract conceptualizations, which are all conditioned by the immediate perception.

Subsequent inquiries into the nature of immediate perception support the idea of a constructed representation of reality. Physics-inspired thinkers were intrigued by our perception of the world. Of particular interest were time and space, namely why introspection into the way we perceive the world tells us that space should be represented with three dimensions and time should be considered a separate dimension, while physical theories and mathematical formalisms could add any number of dimensions and consider time as one among them. Poincaré (1912) argued that this particular structure stems from the biological structure of our cognitive apparatus, and surmised the existence of a faculty that enables us to construct physical and mathematical continuums, and also enables us to construct 'spaces' with different number and configuration of dimensions. Rashevsky (1935, p. 75), the founder of a field called mathematical biophysics, even attempted to imagine "what the physico-chemical structure of organisms must be so that they would choose for their frames of reference our three-dimensional space and one-dimensional time," warning that "this structure must itself be described in non-spatial and non-temporal terms." Biology-inspired thinkers extended this line of thought to argue that such innate 'distortions' are adaptations that ensure our survival, among others, by focusing our attention on certain aspects of reality and excluding others. Maturana and Varela (1980) proposed the concept of autopoiesis, as the tendency of some systems to reproduce the relations that sustain their

existence. The ‘perception’ of autopoietic systems refers to the system itself, by selecting only those external features that are of interest in relation to system survival. For example, unaided human perception only represents a range of wavelengths in the electromagnetic or sound spectrums, as well as objects and processes in a limited range of size, proximity and speed. In other words, we construct a world of our ‘size’ and ‘likeness,’ which, among others, translates into safety and ergonomic concerns for project site equipment operation, and for the design of projects from military aircraft to information systems (Shneiderman, 1979).

Psychologists and neural scientists provide more evidence in support of the constructed nature of our representations. For example, they found a powerful ability to set apart objects from ground, or to discern the features and expressions of other people. For gestalt psychologists and neurobiologists, these abilities amount to an active construction of the world by our brain (Kohler, 1938; Wertheimer, 1938; Maunsell, 1995; Zeki, 1992). A first operation involved in “seeing with the brain” enables us to spontaneously see objects as an instantiation of a category. Many such categories, including social ones, point to the function of an object or to the way it affects the subject (Polanyi, 1966; Dreyfus, 1991; Rosch, 1978). Perceiving objects directly as meaningful, for instance as a friend or a foe, is an adaptation that enables us to react more quickly to dangers. A second constructive “distortion” that our brain performs almost automatically is putting objects in relation (Anderson, 1980; Damasio, 1989), such as apprehending their relative position, sequence, movement, or causal influence. The two operations are not only basic, but also independent, as suggested by the fact that our brain uses separate neural circuits to perform them (Kandel, 2006).

According to Schopenhauer, our representation of the world also involves the ability to create and operate with abstract categories. In line with the rational views mentioned above, this

uniquely human ability to "withdraw into reflection," in a "sphere of calm deliberation" away from the "storms of reality" (Schopenhauer, 1966, p. 85) is the key to planning future actions and increasing our control over the world. However, he also argues that abstract concepts are rooted in our perception of the world and, hence, are conditioned by the operations that construct this perception. Besides, while perception gives us a direct and, in some sense, infallible grasp of the world, abstract representations are prone to errors with regard to the meaning of concepts and the relations between them. These ideas are echoed by epistemological perspectives that see only a loose correspondence between abstract constructs and the reality "out there," from those insisting on the primacy of the logical structure of a network of concepts over its correspondence with the sensations we get from reality (Bunge, 1996), to those observing that conceptual nets "impinge on reality only at the margins" (Quine, 1951), or not at all, as concepts derive meaning from their relation to each other (Wittgenstein, 1953).

Such debates are paralleled in the literature on technology by discussions on the role of abstract knowledge, such as scientific formulas, in representing and guiding the design concrete artifacts, for example in innovation projects. While some authors (Bunge, 1967; Sorenson & Fleming, 2004) maintain that abstract knowledge plays an important inspiring and guiding role, others (Vincenti, 1990; Nightingale, 1998) argue that abstractions have a hard time capturing the complex forms of technical objects, and may even be counterproductive (Kline, 1987). The alternative is developing an intuitive understanding of the operation and "affordances" (Gibson 1977) of relevant concrete objects, through immediate perception and practical experience, such as that obtained through repeated prototype trials. A similar debate, with relevance for project selection activities, ensued in psychology and decision theory from the finding that decision makers systematically deviate from the norms of "substantive rationality" (Tversky &

Kahneman, 1974). A more adaptive behavior seems to be interacting repeatedly with the concrete reality and iteratively improving the representation of the situation rather than seeking an optimal decision scheme from the outset (Simon, 1978; Einhorn & Hogarth, 1981). These findings are, perhaps, echoed in the growing popularity of iterative, as opposed to linear, project processes, including Scrum (Boehm, 1988; Schwaber, 1997; Shenhar, 2001).

Human limitations and abilities also explain the widespread production of representations on external, material supports, such as paper and computer screens, in the form symbolic formulas, drawings, imagery and videos. Some of these representations, such as those provided by an electronic microscope or a particle detector, enable us to overcome perceptual limits. But the means by which they are produced add another thick constructive layer, via the theoretical assumptions incorporated in the design of the relevant devices and practices, even simple ones such as optical microscopes (Hacking, 1981; Pickering, 1981). Similar constructive distortions operate in the devices investigating soil conditions for a hydroelectric dam project, the size of an oilfield for a drilling platform project or the biological processes that justify a drug project.

Other benefits of external representations are the possibility of preserving impressions and abstractions to overcome memory limitations, and of conveying them in time and space to overcome the limitations of presence. Moreover, external representations also give feedback on imagined objects by letting us glance at their concrete form in the world, and manipulate them in ways that mental abilities do not allow. This is particularly useful for architects, engineers and industrial designers who, in essence, construct project representations by relying on nonverbal thought (Fergusson, 1977; Visser, 2006). Like constructing mental representations, constructing external ones involves selection, accentuation, meaning attribution and relational configuration (Lynch, 1988), but these distortions are combined with processes of materialization and

preservation on external media, which impose their own set of constraints (Latour, 1986). In some cases, the process also involves representational conventions that abstract in a particular directive way from the richness of perceptual representations (Henderson, 1991; Zasso, 1996). These insights in the nature of mental and external representations suggest that knowledge production and representation practices in projects do not just passively enhance correspondence with a reality out there, but actively construct a reality, via multilayered, partly implicit processes of perception, conceptualization, codification and embodiment. The construction seems even less anchored and more active when prospective representations, such as project plans and drawings, are being produced. Results may differ, depending on specific actors, tools and operations involved in these processes, and hence may channel projects on quite different action paths.

Social processes add another distortive layer to the process of representation construction. Theories about the social construction of reality (Berger & Luckmann, 1966; Bourdieu, 1977), in particular the sociology of science, technology and risk (Fleck, 1979; Hughes, 1983; Latour & Woolgar, 1979; Douglas & Wildavsky, 1982), imply that rather elaborate processes of collective selecting, amplifying, forgetting and legitimizing are enmeshed in the construction of concepts and causal attributions used in practice and science. In turn, these influence individual perception and action. These theories can help us understand the practices through which the 'myth' of project viability and worth is built and maintained, but also the strategic practices that encourage or limit the access and influence of possible participants in the process, or impact decisions by setting the discussion agenda, framing the key issues, legitimating and otherwise structuring the field of possible action (Foucault, 1982; Dutton & Jackson, 1987; McCombs & Shaw, 1993).

Representations on external, material support play a key role in these processes, first of all as vehicles for conveying internal representations, such as project visions or personal and tacit

knowledge, to other actors, present in the same room, or located further away in space and time. Studies of engineering design and innovation projects suggest that a multitude of representations are used, some to synthesize, convey and legitimate knowledge, either existing or produced in the course of project activities, while others, to represent requirements, functions, architectures, artefact forms and schedules that guide execution; the nature of representations seems to evolve from abstract and simple to concrete and complex as the project advances (Floricel, Michela, & George, 2011; Chandrasegaran et al., 2013). Research on external representation practices traced sequences or networks of representations that converge towards a definitive "inscription" which legitimizes the project myth (Henderson, 1999; Latour, 1986). It also elucidated how external representations are used to enable collaboration. As "boundary objects" (Star & Griesemer, 1989; Carlile, 2002) they enable the coordination of planning activities across organizational and departmental boundaries by helping create a shared vocabulary and meaning, while as "epistemic objects" (Ewenstein & Whyte, 2009; Knorr Cetina, 1997) their joint construction helps integrate the contributions of planners working together. A key condition for collaboration seems to be the flexibility allowed by various forms of embodiment, say by a pencil and paper sketch compared to an electronic database (Henderson, 1991).

External representations can also be a vehicle for "translating" the project in an attempt to attract, tame or repel other actors or to create a "screen" that projects the needed image for stakeholders (Callon, 1986). Their morphologic, figurative and symbolic structure, as well as their dynamic properties, convey meaning by interacting with actors' innate perceptual and conceptual abilities discussed above. The study of practices involving such representations, from written slogans and graphic materials to final artifacts, can illuminate their use as "discursive instruments" for influencing others actors (Deetz, Tracy & Simpson, 2000). The selection and

active manipulation of representations is also used to project the competence, probity, diligence and reliability of the actors that produced them, and hence, to augment their status, legitimacy, credibility, and, ultimately, their potential influence on other actors (Floricel, Michela & George, 2011). For example, during the Polaris system development, PERT charts served, among others, to demonstrate the use of modern management practices and hence keep public bureaucrats from interfering with the project (Sapolsky, 1972).

The above discussion reveals that representations could be viewed differently compared to the assumptions of the rational paradigm in project management. Rather than being knowledge that reflects, albeit imperfectly, the reality surrounding a project, they are distortions resulting from biological, psychological and social processes. Instead of providing objective justifications for projects, they are used as tools for convincing and manipulating. But even if this richer, albeit not unusual view, is adopted, our understanding of projects may suffer from the overemphasis on representations imported from the social and organization theories that inform project research. These theories have been dominated by phenomenology inspired views regarding the social construction of reality and the various forms of institutionalization of structures and practices (Berger & Luckmann, 1966; Giddens, 1984; Meyer & Rowan, 1977). These views had multiple echoes in organization theory, from the information processing view (March & Simon, 1958; Stinchcombe, 1990), to an emphasis on tacit knowledge (Nonaka, 1994), routines (Nelson & Winter, 1982; Feldman & Pentland, 2003), sensemaking, identity and heedful behavior (Weick, 1979; Gioia & Chittipeddi, 1991), and even on ‘practice’ as a corpus of accepted ways of doing things (Jarzabkowski, Balogun & Seidl, 2007). Project management has followed the same trend (Blomquist, Hällgren, Nilsson & Söderholm, 2010). Only recently have these fields started to pay attention to external representations and their organizational role as boundary or epistemic

objects (Scarbrough, Panourgias & Nandhakumar, 2015). Also recently, currents such as actor-network theory, activity theory, sociomateriality and the practice view (Latour, 2005; Engeström, 2001; Orlikowski, 2007; Nicolini, Mengis & Swan, 2012) started to explore the way social interactions are intertwined with various material aspects of the world. We believe that Schopenhauer's concept of 'will,' discussed in the next section, opens an avenue for better understanding the volitional and material aspects of project management as well as for their rebalancing and integration with the representational aspects.

Will

This second aspect of our relation to the world that Schopenhauer puts forward is related to inner sensations such as pain, pleasure, emotion, desire and urges to act. He sees these sensations as vehicles through which a fundamental 'will' present in the world expresses itself. The intuition of these inner states, unencumbered by words and concepts, is for him a way of glimpsing the intrinsic nature of the world—a holistic eternal force that manifests itself through a multitude of subjects in particular times and places. Another expression of 'will' is the never-ending struggle for domination between subjects, including that between human and non-human subjects, or with non-living forces. Simply put, a multiplicity of subjects are vehicles, at a specific place and time, of this universal force, which subjects cannot represent as an object, but which acts through their bodies and can be glimpsed via introspection. Contrary to Nietzschean or existentialist views that emphasize the autonomy of individual volition, Schopenhauer argues that the feeling of individual free will in human subjects is an illusion, enabled by the higher levels of organization of the human body.

Schopenhauer vision of ‘will’ appears to have been influenced by Hinduism (Nichols, 1999; White, 2010). Other possible influences are ancient mystical notions, such as Dionysian or Bacchic cults in ancient Greece and Rome, which opposed the rational cult of Sun’s god Apollo, and whose ceremonies, by diminishing actors’ restraint, let followers express and connect with the irrational forces that rule them. These ideas made Schopenhauer a preferred philosopher of Romanticism, an intellectual current that, in reaction to Age of Enlightenment with its emphasis on knowledge, individual freedom and rationality, rediscovered ancient Nordic myths and their beliefs that occult magical forces rule the world (Williamson, 2004).

In spite of these sources, Schopenhauer’s view is surprisingly compatible with modern scientific views of a material world. Thus, Schopenhauer’s always unsatisfied ‘will’ is akin to the impetus present in the Universe since, say, the Big Bang, whose nature and origins still elude our ability to understand it as a fully re-presentable object. One of the many diffuse consequences of this impetus is the development of living organisms, including the human species. Each organism can be seen as a temporary nexus of processes in the vast network of transformations that this impetus generates in the world. Its particular form is an echo of transformations, such as evolutionary adaptation, that follow obscure logics, perhaps as strange as that supposed by Dawkins’s (1976) “selfish gene” hypothesis. The peculiarities of this form, including the a priori representational abilities and the sensations it produces in subjects, are geared towards the survival of the body and the reproduction of its species.

The idea of a magic underground that influences phenomena in the world in intractable ways is also echoed in the modern scientific views. Scientists are still debating fundamental properties space, time, energy and matter, as well as the nature of subatomic particles and the processes involving them. Current thinking about them includes notions that call in question

traditional conceptions of space, time and causality, such as relativity, intrinsic randomness (rather than lack of knowledge) and limits to observation. Yet, even with these assumptions, the world cannot be explained using a parsimonious set of concepts related in simple ways. Streams of thought attempting such explanations, for example string theory, make strange assumptions, so strange that no mathematical apparatus is available to work out any testable hypotheses (Greene, 1999). Among others, they postulate entities that lack normal dimensionality but also spaces with many additional hidden dimension. What Romantics saw as occult, telluric forces, is now the almost infinite potential for surprising discoveries in what Feynman (1960) called "plenty of room at the bottom."

But the idea of intractable influences beyond our representation and abstraction abilities is also relevant at a more macro, everyday level, and transpires in the debates on complexity, emergence and process ontologies. Of the various views on complexity (Biggiero, 2001), closer to the concept of 'will' appears to be the one focusing on the fact that interactions between entities at a lower-level of organization, and/or between their properties, lead to unexpected properties in higher-level objects. System philosophers call this possibility 'emergence' and argue that it gives higher-level entities a distinct ontological status; emergent entities exist in their own right (Bunge, 1979; Simon, 1981). Complexity in this sense increases with the extent that component aggregation is non-additive and emergent properties cannot be reduced to the properties of component entities and of their interactions. In other words, we cannot represent the origin and the impetus for many entities that we observe in the world. The nature of emergence and non-additivity itself is still the object of heated debate (Wimsatt, 2006). All this gives phenomena, including project-relevant ones, such as those related to materials, air or fluid

dynamics, and soil, an aura of ‘magic’ despite spectacular advances in science and technology in the two centuries since Schopenhauer’s book.

Added complexity of this type comes from the ‘downward conditioning’ (Kontopoulos, 1993) that higher levels of organization exert over their components, especially in the sense of maintaining the relations that led to their emergence in the first place. Upward from molecules, biological entities have been characterized by multiple interactions between up to nine emergent levels of organization (Kohl & Noble, 2009, p. 3). The failure to explain and especially to predict these phenomena by focusing components such as genes and proteins led to calls for abandoning the prevalent reductionist stance in biology and adopting a more systemic, cross-level approach (Mayr, 2000; Sauer, Heinemann & Zamboni, 2007; Noble, 2010). In practical terms, this failure, relevant for pharmaceutical, biotechnology and biomedical projects, seems to account for the extremely low percentage of successful projects, for the low level of success of ‘rational drug design’ approaches, and hence, for the continuing prevalence of massive trial and error approaches that seek to find a way of tricking the ‘magic underground’ to do what project participants want it to do (Nightingale & Martin, 2004; Mandal et al., 2009).

The ideas of emergence and downward conditioning have also characterized the efforts to account for the complexity of social reality. Researchers set apart several aggregation levels, from individuals, to teams, organizations (including projects), sectors, nations and global systems, but struggle to understand how these interact. While some scholars, particularly economists, try to explain the properties of higher level systems by looking at the interactions between lower level entities (Axelrod, 1984; Coleman, 1966), others emphasize the influence of higher levels on the organization of lower levels (Parsons, 1960; Meyer & Rowan, 1977; Luhmann, 1995), while a third group stress mutual influences between various levels (Bourdieu,

1977; Giddens, 1984). The diversity of possible interactions may account for the fact that project organizations do not obey the tenets of rational design; their emergence from multiple types of relations between various types of human and nonhuman entities adds layers of complexity on top of those attributable to intractable interactions in their material and biological substrate.

Another stream of thought that supports the inscrutable and dynamic nature of 'will' concerns natural and social processes. According to Prigogine (1997, p. 55), we live in a world in which "we discover fluctuations, bifurcations and instabilities at all levels." One line of inquiry into processes still considers entities as real and focuses on the conditions and mechanisms that produce highly non-linear or chaotic dynamics in the systems of interests (Van de Ven & Poole, 1995; Dooley & Van de Ven, 1999). Of particular interest are conditions and mechanisms through which small, imperceptible differences in initial conditions lead to wildly different outcomes, for example for competing innovation projects (Arthur, 1989). But, on the other hand, proponents of so called 'process ontologies' consider that entities are artifacts of our perception, and that events, which make a difference in the world and connect to each other to form processes, are the essential elements of the world (Hernes, 2008, p. 45, referring to the work of Alfred North Whitehead). Processes are detectable strands of events in a world in continual becoming (Hernes & Weik, 2007). Organization scholars influenced by this ontology argue that continual becoming is the normal state of organizations and the only way to influence its course is by interacting in order to reweave some of the processes (Tsoukas & Chia, 2002). This process view provides strong arguments against the rational 'practice' of attempting to 'freeze' project deliverables and organizations up front, through plans, organizational charts and contracts; in fact it suggests that to manage projects is not to sanction deviations but to embrace and perhaps stimulate continuous change processes.

Schopenhauer's argument that perception is conditioned by innate structures, and that we perhaps get a more direct access to 'will' through bodily sensations, such as emotions, has also been supported by subsequent developments. The discovery of unconscious sources of human behavior (Freud, 1953), some of which may be deep structures shared across the human species (Jung, 1965; Schein, 1985); the mapping of cognitive functions and subjective sensations on specific areas and processes in the brain, nervous and other somatic systems (Changeux & Dehaene, 1989; Le Doux, 1995; Cabeza & Nyberg, 2000; Kandel, 2006); as well as studies in evolutionary psychology (Tooby & Cosmides, 1992; Pinker, 1999) all seem to support the idea that representations and emotions are the result of the lines of force that express the original impulse working through the body. Rather than producing a "mirror" or "true" representation of some external reality, evolution developed living forms that harmonize with these lines of force by constructing biochemical and physiological 'representations' and perceptual sensations and by triggering actions, which, in spite of their seeming irrationality, are crucial for maintaining the relations that ensure the survival of individuals and species (Maturana & Varela, 1980). The implications of these findings for project management research and practice go well beyond the tenets of the 'human side of project management' current, which opposes a view of project actors as malleable and rational executants that can be managed mechanically (Block, 1983; House, 1988). While relying on psychology, ergonomics and political science to suggest a more nuanced understanding of actors, the 'human side' perspective still aims to subsume any complications to the 'rational' project management view, by identifying relevant stimulus-response regularities and, from a cognitive perspective, by accounting for intervening biases and distortions. Instead, the new views, which correspond better to Schopenhauer's 'will', de-center away from humans,

by stressing their complex and multifaceted material and biological roots and by treating human and nonhuman entities in a symmetric and inextricably related manner (Latour, 1991).

The relevance of the ‘concept of will’ for project management is echoed by recent trends in research and practice. In a sense, the unpredictable and always becoming nature of the world is already captured by the interest in risk, in particular in unforeseen events (Floricel & Miller, 2001; Sommer & Loch, 2004), and complexity (Shenhar, 2001; Williams, 1999). Research on complexity in project management has taken two paths (Geraldi, Maylor & Williams, 2011). One aims to take a deeper look at the nature of project complexity, to enable a critical reassessment of prescribed project management methods (Whitty & Maylor, 2009), while the other prefers the more practical approach of mapping the vast diversity of factors that increase project complexity (Bosch-Rekveldt, Jongkind, Mooi, Bakker, & Verbraeck, 2011). These studies can be further divided in two strands, one static and the other dynamic, a distinction similar to the one we made above (Benbya & McKelvey, 2006). In terms of substantive areas, the inquiry included technical aspects (Kim & Wilemon, 2003; Lu & Suh, 2009) as well as the market, social and political environment, the networks of contractors and stakeholders, the nature of organizations and teams etc. (Floricel, Piperca & Banik, 2011).

However, we believe that the concept of ‘will’ can improve our understanding of the forces at work in project management to a much larger extent than research on complexity has been able to do so far. First, it can help us take a fresh look at the broad range of intractable and dynamic ways in which materiality intertwines with projects, as suggested by researchers interested in sociality with objects (Knorr Cetina, 1997), actor-networks (Callon, 1986), and sociomateriality (Barad, 2003; Orlikowski, 2007). In our own research we repeatedly found that, despite the availability of statistical knowledge and advanced technical means, project managers

had to confront unforeseen soil and weather conditions. Situations in which the support of a bridge or the base of a dam could not reach solid rock because they fell on a surprisingly deep geological deposit or even on a tectonic fault line are common. Echoing the occult telluric forces of Romanticism, it seems that complex projects regularly encounter 'black swans' that reveal the fragility of past statistical knowledge (Taleb, 2007). Thus, even more common are occurrences of biological processes that block the action of drugs for reasons that are impossible to predict or even understand, of unsuspecting responses of living organisms and ecosystems involved in or affected by projects, as well as of artifacts that stubbornly refuse to behave as designers intended. Failures during execution and exploitation, often having severe consequences, or even the inability to separate and coordinate work and traffic flows on construction sites are other frequent examples. This has inspired some thinkers to argue that a constant risk of technical catastrophes and major unintended consequences of innovation and other complex projects is the normal state of affairs in modern societies (Beck, 1992; Kenway et al. 2006). Echoing the Romantic-era vision of a magic underground Perrow (1984: 11) argued, after studying the Three Miles Island that "socio-technical systems have become so complicated that we cannot anticipate all the possible interaction of the inevitable failures; we add safety devices that are deceived or avoided or defeated by hidden paths in the system."

Given the vast network of material and logical interactions that constitute a project today and the abundance of surprising events, the project management field started to emphasize practices such as gradual or iterative definition of scope and requirements (MacCormack, Verganti & Iansiti, 2001), lean (just-in-time, moderately in advance) planning of activities (Ballard & Tommelein, 2012) and agile or improvisational execution (Conforto, Salum, Amaral, da Silva, & de Almeida, 2014; Leybourne, 2009); to seek ways to detect early warning signs of

project failure (Kappelman, McKeeman & Zhang, 2006); and to increase the response capacity of project organizations (Floricel, Piperca & Banik, 2011). Others have insisted that reducing the chances of such events relies on the development of network coordination capabilities (Brusoni, Prencipe & Pavitt, 2001) and even to a total reshaping of the institutional framework that surrounds the development, execution and exploitation of projects (Leveson et al., 2009). Even for projects such as software, information and communication systems, in which designers assume that material aspects are under control, and only deal with representations, such as strings of bits, they have become concerned with the complexity of representations themselves (Tergaden, Sheetz & Monarchi, 1995; Katina, Keating & Jaradat, 2014). Experts struggle to define and quantify the static complexity of such virtual systems, often conceptualizing it as the difficulty of representing system regularities in a simplified manner, together with the computational effort required for retrieving its form with a given degree of precision (Kolmogorov, 1965; Gell-Mann & Lloyd, 1996).

But the concept of 'will' can also be used to better understand the role and behavior of human actors, beyond the view of selfish opportunism 'with a guile' (Williamson, 1981), but still calculating and utility maximizing, which economists propose, and towards a much broader range of rational and non-rational behavior, driven by urges stemming from actors' material and biological nature. This view can accommodate behavior affected by greed, libido, resentment, fatigue, stress, disease, including mental one, the use of alcohol and drugs, etc. Our own research on complex projects has revealed frequent conflicts not only with stakeholders such as pressure groups and trade unions, but often between participants. These conflicts were often based on personal animosity, and sometimes led to threats, violence and other types of criminal behavior, and often could be resolved only by removing some of those involved from the project. We also

observed how this kind of conflict was exacerbated by unexpected problems related to project environment and artefacts. Of course this view can also account for seemingly 'random' creativity, entrepreneurial brilliance and energy as well as altruism, solidarity and heroism in dangerous situations. Despite the recent importance that organization theorists are beginning to attach to emotions (Huy, 1999), neural micro-foundations of organizational behavior (Hodgkinson & Healey, 2011) and even criminal behavior (Crane, 2013), this range of non-rational behavior is still rarely considered in project management research (Müller et al., 2013).

All these aspects uncovered by using the concept of 'will' also enable a rethinking of the impetus for initiating and carrying forward projects as a diversity of processes conditioned by their material substrate. This later condition puts on an equal epistemological footing the human and non human beings as well as project artifacts and natural surroundings, which all become actors of sorts (Latour, 1991; Law, 2004). Indeed participants' and stakeholders' needs, desires, intentions as well as fears, urges to act and to dominate, as well as underlying natural processes in artifacts and soil, are all expressions of 'will' through different vehicles. In rational views, some of these expressions translate into goals, functions, value or utility, while others are interpreted as costs, constraints and risks. Yet, these translations operate on processes that can hardly be understood and represented, such as those that work through the body to ensure survival or those that work in project surroundings to produce earthquakes and hurricanes. As a result, goals and value are bound to be arbitrary in light of any representation of the world, as expressed in such observations as "rules of morality […], are not conclusions of our reason," (Hume, D., 1739, A Treatise of Human Nature, Book III, Part I, Sect. 1), and "nothing that *ought* to be can be deduced by knowing what *is*" (Polanyi, 1966, p. 44, italics in the original).

A corollary of having such a shaky base is that goals and value assessments by different project participants are likely to be in conflict, even when they are couched in altruistic urges or when surrogates of causal representation, such as cultural values, social norms and tradition serve as justifications (Habermas, 1968). Conflicts force project participants and stakeholders to change positions or induce other actors to change theirs. Besides, while a current assessment may reflect fundamental forces and longstanding traditions, the dynamic components of survival-oriented bodily processes constantly react to changing stimuli. In particular, the impetus that works through non human and inanimate material substrates will produce events that will be perceived as unexpected by project participants (Luhmann, 1993). This will trigger reactions in some actors, which will change their goals and assessments of value and will induce other actors to change their desires accordingly. Therefore, project goals or technical specifications that "fix" these assessments of value can only be taken as temporary representations of untamed and ill understood expressions of 'will' through subjects. This also means that the teleological engine and the linear unfolding patterns, implicit in the dominant plan-then-execute paradigm for project management, are not a valid description of project processes, and should be replaced, perhaps by dialectic or evolutionary engines and by continuous becoming processes, as well as by practices that constantly reassess the context and participants' goals and attempt to continually rebuild the nexus of commitments towards the project.

The relation between 'will' and 'representation'

In Schopenhauer's view, 'will' and 'representation' are two sides of the same coin, which amounts to an automatic link between the two. Hence, he stresses the importance of representations in the form of "intuitive, immediate apprehension", by arguing that "abstract

concepts of reason can only serve to handle what is immediately understood […] but never to bring about understanding itself" (1966, p. 21). In turn, apprehension is conditioned by the innate manifestations of 'will'. Theories of evolutionary cognition and autopoietic systems, which we mentioned before, as well as pragmatism (Simpson, 2009), situated action (Suchman, 1987) and activity theory (Leont'ev, 1978), connect 'will' to 'representation' via the argument that the latter is oriented internally, towards inner states and activities that ensure the survival and maintenance of the body or other relevant systems. This link is supported by evidence from psychology and neurobiology research about the importance of emotions, an expression of 'will' in subjects, for regulating cognition and adaptive behavior (Zajonc, 1984; Damasio, 1989; Storbeck & Clore, 2007). Additional support comes from the importance that scientists, including famous physicists such as Einstein and Pauli, give to introspection when attempting to understand the world (Miller, 2009). Evidence even shows that "bioregulatory signals, including those that constitute feeling and emotion, provide the principal guide for decisions" (Bechara, Damasio & Damasio, 2000, p. 307). This may also explain the crucial role of volition, along with perceptual abilities and experience, in constructing representations of useful artificial objects, for example inventing new operating principles or designing new projects (Mitcham, 1994).

In turn, perceptual representations of the world and their cognitive processing interact with subjects' volition, triggering evaluative and emotional reactions, and sometimes becoming an impetus for action, such as initiating a project. Externalized representations, become objects in the world, and have a similar effect by interacting with subjects' perceptual and understanding abilities. For example, the fact that subjects have a visceral reaction to certain types of material stimuli is well known, and exploited by marketing experts (Zaltman & Coulter, 1995). But subjects also appear to evaluate emotionally abstract representations such as expected values and

probability distributions. Hence, in decision experiments, subjects express inordinate preference for alternatives that are certain or for menus of alternatives with known probability distributions, as opposed to more uncertain distributions (Allais, 1953; Ellsberg, 1961). Shifting a representation of prospective action outcomes from an achievement that falls short of the subject's aspirations to a possible demise of the subject is accompanied by an emotional shift "between hope and fear" (Lopes, 1987). Also, studies of managerial decision-making in natural settings show that subjects react to risk as they react to dangers. They do not engage in calculations of variance and probabilities, and focus only on the extreme values of the outcome, instead of the entire distribution (Shapira, 1995; MacCrimmon & Wehrung, 1986). The project management domain is just starting to pay attention to this interaction in order to identify the kind of representations that can be used to introduce a project to stakeholders and to structure public hearings and decisional debates (Lehmann & Motulsky, 2013).

As a consequence of (i) the constructed nature of representations about the project, its context and its viability, and of the additional construction and possible manipulation involved in the production of external representations, (ii) the unstable expressions of 'will' in human and nonhuman actors, and (iii) the many possible interactions between representations and expressions of 'will' such as goals and perceptions of value, projects are not likely to converge towards a static equilibrium of actors' positions, as assumed implicitly by rational theories, but will advance through a constant repositioning and rebuilding process. However, we argue that visibility in the social arena stabilizes some project representational elements. Such elements include both input assumptions and output representations, such as studies, designs, plans and contracts, which are available to most participants, as well as initial positions and, especially, resulting commitments, which were made public and are considered to be the tamed or regulated

aspect of the participant's volition. Because they result from lengthy discussions and negotiations and changing them sends strong signals about the respective actors and interferes with implementation activities, elements in the social arena are likely to remain stable for a certain time. Though, behind this screen of stability participants' representations and expressions of will are constantly shifting and the accumulated tensions are always ready so disrupt the apparent stability. As a result, outside observers will likely perceive the redefinitions that take place in planning as a punctuated equilibrium process.

Instead of conclusions: If Schopenhauer were a project manager today …

Some may perceive the preceding discussion as a call for returning to old romantic myths about the world and importing them into project management. However, we hope that the arguments that we provides suggest quite the contrary, namely taking a more lucid look at the reality of project management, one that is informed by the latest discoveries in a whole range of sciences, from physics and biology to social sciences, and includes a much broader range of relevant aspects. In the process, it may well become evident that, in fact, the current rational-normative approaches to project management are based on no more than a myth (Meyer & Rowan, 1977). We used Schopenhauer's discussion of the world as 'will' and 'representation' as the kernel that not only enabled us to articulate all these discoveries in an integrated and parsimonious framework, but also to rebalance what we saw as an excess of attention to cognitive and representational aspects as the expense of material and volitional aspects. In more concrete terms we believe that this framework enables reconsidering various aspects of project management from new perspectives.

First, this framework allows for rethinking project organizations in a way that includes a much broader range of ways in which people are connected, by including not only rules, charts and plans, or routines and interaction scripts, but also physical attraction, repulsion, threats and force, as well as material objects, from forms to be filled and information systems that embody power differentials through pre-set access rights; to surveillance systems, alleys, walls and fences that constrain, warn or isolate people; and to tools that embody past experience and convey it across time and space.

Second, rethinking the role of representations, in particular those on external supports, in their various hypostases, from project 'translations' that convince and 'attract' actors to projects, securing convergence and commitment, inspiring and guiding action; to distorted constructions that mislead and cause problems; and to artefacts that can be manipulated for illicit gain and used for window-dressing to fend off surveillance. From this perspective, planning no longer can be seen as the construction of an objective and integrated, albeit evolving, representation of the future project, but rather as a distributed process of bricolage that struggles to accommodate opposing interests, conflicting institutional logics and disparate sensemaking strands, to create some sort of assemblage, often from accidental, marginal and reused components, and hold it together by way of narratives and rhetoric (Baker & Nelson, 2005; Suddaby & Greenwood, 2005; Lounsbury & Glynn, 2001; Weick, Sutcliffe & Obstfeld, 2005).

Third, this framework argues squarely that project participants are biological and material beings, evolving in a material world that acts in ways that cannot be totally understood, and that conditions their urges, perceptions and cognitions in significant yet not completely tractable ways. This would perhaps enable the inclusion of a much broader range of desires, behaviors and actions in the range of the normal (which does not mean that all of them are condoned), and

hence develop theories that enable managers to better prepare for their occurrence rather than relegating them to problems and unexpected events. This would also call for considering multiple levels at which the various aspects of the world interact and condition each other.

Fourth, this framework suggests that our thinking of projects should be much more dynamic, in fact, extremely dynamic. As mentioned above, projects are a more or less connected nexus of processes, in which a variety of manifestations of 'will' connect and collide in multiple ways. Stabilizing elements are scant, and over-enforcing them is probably counterproductive, as constantly shifting stimuli and volitions may cause the outburst of accumulating tensions. Projects are thus better seen as continually changing or becoming. Some groups of representations and associated manipulations and rhetoric may play a temporary stabilizing role, which would enable advances in planning and execution in ways that are somewhat under control. But such representations more likely amount to ill-assembled rafts floating on the agitated sea of 'will'. As a consequence, our vision of project management should shift from that of maintaining a straight line, like a liner would do on an ocean by correcting deviations from the preset trajectory, towards one of a collective struggle of maintaining convergence and advancement while dealing with representational inconsistencies and aberrations, as well as with the constant shifts and conflicts in the manifold manifestations of 'will'.

REFERENCES

Allais, M. (1953). Le comportement de l'homme rationnel devant le risque: critique des postulats et axiomes de l'école américaine. *Econometrica: Journal of the Econometric Society*, 21(4), 503-546.

Anderson, J. R. (1980). *Cognitive Psychology and Its Implications.* New York: W. H. Freeman.

Arthur, W. B. (1989). Competing technologies, increasing returns, and lock-in by historical events. *The Economic Journal*, 99(394), 116-131.

Axelrod, R. (1984). *The Evolution of Cooperation*. New York: Basic Books.

Baker, T., & Nelson, R. E. (2005). Creating something from nothing: Resource construction through entrepreneurial bricolage. *Administrative science quarterly*, 50(3), 329-366.

Ballard, G. & Tommelein, I. (2012). Lean management methods for complex projects. *Engineering Project Organization Journal*, 2(1-2), 85-96.

Barad, K. (2003). Posthumanist performativity: Toward an understanding of how matter comes to matter. *Signs*, 28(3), 801-831.

Beck, U. (1992). *Risk Society: Towards a New Modernity*. London: Sage.

Bechara, A., Damasio, H. & Damasio, A. R. (2000). Emotion, decision making and the orbitofrontal cortex. *Cerebral Cortex*, 10(3), 295-307.

Benbya, H., & McKelvey, B. (2006). Using coevolutionary and complexity theories to improve IS alignment: a multi-level approach. *Journal of Information technology*, 21(4), 284-298.

Berger, P., & Luckmann, T. (1966). *The Social Construction of Reality.* Garden City, NY: Doubleday.

Biggiero, L. (2001). Sources of complexity in human systems. *Nonlinear Dynamics, Psychology, and Life Sciences*, 5(1), 3-19.

Block, R. (1983). *The Politics of Projects.* New York: Yourdon Press.

Blomquist, T., Hällgren, M., Nilsson, A, & Söderholm, A. (2010). Project-as-practice: In search of project management research that matters. *Project Management Journal*, 41(1), 5-16.

Boehm, B. (1988). A spiral model of software development and enhancement. *IEEE Computer*, 21(5), 61–72.

Bosch-Rekveldt, M., Jongkind, Y., Mooi, H., Bakker, H., & Verbraeck, A. (2011). Grasping project complexity in large engineering projects: The TOE (Technical, Organizational and Environmental) framework. *International Journal of Project Management*, 29(6), 728-739.

Bourdieu, P. (1977). *Outline of a Theory of Practice.* Cambridge, UK: Cambridge University Press.

Brucker, P., Drexl, A., Möhring, R., Neumann, K., Pesch, E. (1999). Resource-constrained project scheduling: Notation, classification, models, and methods. *European Journal of Operational Research*, 112(1), 3-41.

Brusoni, S., Prencipe, A., & Pavitt, K. (2001). Knowledge specialization, organizational coupling, and the boundaries of the firm: Why do firms know more than they make? *Administrative Science Quarterly*, 46(4), 597-621.

Bunge, M. A. (1996). *Finding Philosophy in Social Science*. New Jersey: Yale Univesity Press.

Bunge, M. A. (1967). Technology as applied science. *Technology and Culture*, 7(3): 329-347.

Bunge, M. A. (1979). *Treatise on Basic Philosophy: Ontology II: A World of Systems.* Dordrecht, Holland: D. Reidel.

Cabeza, R. & Nyberg, L. (2000). Imaging cognition II: An empirical review of 275 PET and fMRI studies. *Journal of Cognitive Neuroscience*, 12(1), 1-47.

Callon, M. (1986). Some elements of a sociology of translation: Domestication of the scallops and the fishermen of St Brieuc Bay. In J. Law (ed.): *Power, Action and Belief: A New Sociology of Knowledge?* (p. 196-223). London: Routledge.

Carlile, P. R. (2002). A pragmatic view of knowledge and boundaries: Boundary objects in new product development. *Organization Science*, 13(4), 442-455.

Chandrasegaran, S. K., Ramania, K., Sriram, R. D., Horváth, I. Bernard, A., Harik, R. F., & Gao, W. (2013). The evolution, challenges, and future of knowledge representation in product design systems. *Computer-Aided Design*, 45(2), 204–228.

Changeux, J.-P., & Dehaene, S. (1989). Neuronal models of cognitive functions. *Cognition*, 33(1-2), 63-109.

Chapman, C., & Ward, S. (1996). *Project Risk Management: Processes, Techniques and Insights.* Chichester, UK: John Wiley.

Coleman, J. S. (1966). Foundations for a theory of collective decisions. *American Journal of Sociology*, 71(6): 615-627.

Conforto, E. C., Salum, F., Amaral, D. C., da Silva, S. L., & de Almeida, L. F. M. (2014). Can Agile Project Management Be Adopted by Industries Other than Software Development?. *Project Management Journal*, 45(3), 21-34.

Cooke-Davies, T., Cicmil, S., Crawford, L. and Richardson, K. (2007). We're not in Kansas anymore, Toto: mapping the strange landscape of complexity theory, and its relationship to project management. *Project Management Journal*, 38(2), 50-61.

Crane, A. (2013). Modern slavery as a management practice: Exploring the conditions and capabilities for human exploitation. *Academy of Management Review*, 38(1), 49-69.

Damasio, A. R. (1989). Time-locked multiregional retroactivation: A systems-level proposal for the neural substrates of recall and recognition. *Cognition*, 33(1–2), 25–62.

Dawkins, R. (1976). *The Selfish Gene*. Oxford: Oxford University Press.

Deetz, S.A., Tracy, S.J. & Simpson, J.L. (2000). *Leading Organizations Through Transition*. London, Thousand Oaks: Sage.

Dooley, K. J., & Van de Ven, A. H. (1999). Explaining complex organizational dynamics. *Organization Science*, 10(3), 358-372.

Douglas, M., & Wildavsky, A. (1982). *Risk and Culture: An Essay on the Selection of Technological and Environmental Dangers.* Berkeley, CA: University of California Press.

Dreyfus, H. L. (1991). *Being-in-the-World.* Cambridge, Mass: The MIT Press.

Dutton, J. E. & Jackson, S. E. (1987). Categorizing Strategic Issues: Links to Organizational Action. *Academy of Management Review*, 12(1), 76-90.

Einhorn, H. J. & Hogarth, R. M. (1981). Behavioral Decision Theory: Processes of Judgment and Choice. *Annual Review of Psychology*, 32, 53-88.

Einhorn, H. J., & Hogarth, R. M. (1981). Behavioral decision theory: Processes of judgment and choice. *Journal of Accounting Research*, 19(1), 1-31.

Ellsberg, D. (1961). Risk, ambiguity, and the Savage axioms. *Quarterly Journal of Economics*, 75(4), 643-699.

Elster, J. (1979). Ulysses and the Sirens: Studies in Rationality and Irrationality. Cambridge, UK: Cambridge University Press.

Engeström, Y. (2001). Expansive learning at work: toward an activity theoretical reconceptualisation. *Journal of Education and Work*, 14(1), 133–156.

Ewenstein, B. & Whyte, J. (2009). Knowledge practices in design: The role of visual representations as 'Epistemic Objects'. *Organization Studies*, *30*(1), 7-30.

Feldman, M. S., & Pentland, B. T. (2003). Reconceptualizing organizational routines as a source of flexibility and change. *Administrative Science Quarterly*, 48(1), 94-118.

Ferguson, E. S. (1977). The mind's eye: Nonverbal thought in technology. *Science*, 197(4306), 827-836.

Feynman, R. P. (1960). There's plenty of room at the bottom. *Engineering and science*, 23(5), 22-36.

Fleck, L. (1979). *Genesis and Development of a Scientific Fact.* Chicago, IL: University of Chicago Press.

Sorenson, O., & Fleming, L. (2004). Science as a map in technological search. *Strategic management journal*, 25(8), 909-928.

Floricel, S., Bonneau, C., Aubry, M., & Sergi, V. (2014). Extending project management research: Insights from social theories. *International Journal of Project Management*, 32(7), 1091-1107.

Floricel, S., Banik, M., & Piperca, S. (2013). The triple helix of project management research: Theory development, qualitative understanding and quantitative corroboration. In N. Drouin, R. Müller and S. Sankaran (eds.): *Novel Approaches to Organizational Project Management Research: Translational and Transformational*. Copenhagen Business School Press, p. 402-429.

Floricel, S., Michela, J. L., & George, M., with L. Bonneau. (2011). *Knowledge representations in innovation projects: Refining the knowledge production plan*. Newtown Square, PA, USA: Project Management Institute.

Floricel, S. & Miller, R. (2001). Strategizing for anticipated risks and turbulence in large-scale engineering projects. International Journal of Project Management, 19(8), 445–455.

Floricel, S., Piperca, S., & Banik, M. (2011). *Increasing project flexibility: The response capacity of complex projects*. Project Management Institute.

Foucault, M. (1982). The Subject and Power. *Critical Inquiry*, 8(4), 777-795.

Freud, S. (1953). *The Interpretation of Dreams*. London: Hogarth Press.

Gell-Mann, M. & Lloyd, S. (1996). Information measures, effective complexity, and total information. *Complexity*, 2(1), 44–52.

Geraldi, J., Maylor, H., & Williams, T. (2011). Now, let's make it really complex (complicated) A systematic review of the complexities of projects. *International Journal of Operations & Production Management*, 31(9), 966-990.

Giddens, A. (1984). *The constitution of society: Outline of the theory of structuration*. University of California Press.

Gioia, D. A., & Chittipeddi, K. (1991). Sensemaking and sensegiving in strategic change initiation. *Strategic management journal*, 12(6), 433-448.

Greene, B. (1999). *The Elegant Universe*. New York: W. W. Norton.

Habermas, J. (1968). *Technik und Wissenschaft als Ideologie.* Frankfurt: Suhrkamp.

Hacking, I. (1981). Do we see through a microscope? *Pacific Philosophical Quarterly*, 62(4), 305-322.

Heidegger, M. (1962). *Being and Time*. New York: Harper and Row. (originally published in 1927)

Henderson, K. (1991). Flexible Sketches and Inflexible Data Bases: Visual Communication, Conscription Devices, and Boundary Objects in Design Engineering. *Science, Technology & Human Values*, 16(4), 448-473.

Henderson, K. (1999). *On line and on paper: Visual representations, visual culture, and computer graphics in design engineering.* Cambridge: MIT Press.

Hernes, T. (2008). *Understanding Organization as Process: Theory for a Tangled World*. New York: Routledge.

Hernes, T., & Weik, E. (2007). Organization as process: Drawing a line between endogenous and exogenous views. *Scandinavian Journal of Management*, 23(3), 251-264.

Hodgkinson, G. P., & Healey, M. P. (2011). Psychological foundations of dynamic capabilities: Reflexion and reflection in strategic management. *Strategic Management Journal*, 32(13), 1500-1516.

Holmstrom, B. (1979). Moral hazard and observability. *Bell Journal of Economics*, 10(1), 74–91.

House, R.S. (1988). *The Human Side of Project Management.* Reading, MA: Addison-Wesley.

Hughes, T. (1983). *Networks of Power.* Baltimore: John Hopkins Press.

Husserl, E. (1931). Ideas toward a pure phenomenology and phenomenological philosophy. New York: Humanities (Original work published in 1913).

Huy, Q. N. (1999). Emotional capability, emotional intelligence, and radical change. *Academy of Management Review*, 24(2), 325-345.

Jarzabkowski, P., Balogun, J., & Seidl, D. (2007). Strategizing: The challenges of a practice perspective. *Human Relations*, 60(1): 5-27.

Jarzabkowski, P. (2003). Strategic practices: An activity theory perspective on continuity and change. *Journal of Management studies*, 40(1), 23-55.

Jung, C. G. (1965). *Psychology of the Unconscious.* New York: Dodd, Mead.

Kandel, E. R. (2006). *In search of memory: The emergence of a new science of mind.* New York: Norton.

Kappelman, L. A., McKeeman, R., & Zhang L. (2006). Early warning signs of IT project failure: The dominant dozen. *Information Systems Management*, 23(4), 31-36.

Katina P. F., Keating, C. B. & Jaradat, R. M. (2014). System requirements engineering in complex situations. *Requirements Engineering*, 19(1), 45–62.

Kenway, J. Bullen, E., & Fahey, J. with Robb, S. (2006). *Haunting the Knowledge Economy*. London: Routledge.

Kim, J., & Wilemon, D. (2003). Sources and assessment of complexity in NPD projects. *R&D Management*, 33(1), 15-30.

Kline, R. (1987). Science and engineering theory in the invention and development of the induction motor, 1880-1900. *Technology and Culture*, *28*(2), 283-313.

Knorr Cetina, K. (1997). Sociality with objects: Social relations in postsocial knowledge societies. *Theory, Culture & Society*, *14*(4), 1-30.

Kohl, P., & Noble, D. (2009). Systems biology and the virtual physiological human. *Molecular Systems Biology*, 5(1):1-6.

Köhler, W. (1938). "Some Gestalt Problems." In *A Source Book of Gestalt Psychology*, Ellis, W. D. (ed.), 55-70. London: Routhledge & Kegan Paul.

Kolmogorov, A. N. (1965). Three approaches to the quantitative definition of information. *Problems of Information Transmission*, 1(1), 1-7.

Kontopoulos, K. M. (1993). *The Logics of Social Structure.* Cambridge, UK: Cambridge University Press.

Latour, B. (1986). Visualization and cognition: Thinking with eyes and hands. *Knowledge and Society*, 6, 1-40.

Latour, B. (1991). *Nous n'avons jamais été modernes: Essai d'anthropologie symétrique*. Paris: France: La découverte.

Latour, B. (2005). *Reassembling the Social: An Introduction to Actor–Network Theory*. Oxford: Oxford University Press.

Latour, B. & Woolgar, S. (1979). *Laboratory Life: The Social Construction of Scientific Facts.* Beverly Hills, CA: Sage.

Law, J. (2004). *After method: Mess in social science research.* London, UK: Routledge.

Le Doux, J. E. (1995). Emotion: Clues from the brain. *Annual Review of Psychology*, 46, 209-235.

Lehmann, V. & Motulsky, B. (eds.) (2013). *Communication et grands projets : les nouveaux défis*. Quebec : Presses Universitaires du Québec.

Leont'ev, A. N. (1978). *Activity, Consciousness and Personality.* Englewood Cliffs, N.J.: Prentica Hall.

Leveson, N., Dulac, N., Marais, K., & Carroll, J. (2009). Moving beyond normal accidents and high reliability organizations: A systems approach to safety in complex systems. *Organization Studies*, 30(2-3), 227-249.

Leybourne, S. A. (2009). Improvisation and agile project management: a comparative consideration. *International Journal of Managing Projects in Business*, 2(4), 519-535.

Lopes, L. (1987). Between hope and fear: The psychology of risk. *Advances in Experimental Social Psychology*, 20(3), 255-295.

Lounsbury, M., & Glynn, M. A. (2001). Cultural entrepreneurship: Stories, legitimacy, and the acquisition of resources. *Strategic management journal*, 22(6-7), 545-564.

Lu, S. C.-Y., & Suh, N.-P. (2009). Complexity in design of technical systems. *CIRP Annals - Manufacturing Technology*, 58(1), 157-160.

Luhmann, N. (1993). *Risk: A sociological theory.* New York: Aldine De Gruyter.

Luhmann, N. (1995). *Social systems*. Stanford University Press.

Lynch, M. (1988). The externalized retina: Selection and mathematization in the visual documentation of objects in the life sciences. *Human Studies*, 11(2), 201-234.

MacCrimmon, K. R., & Wehrung, D. A. (1986). *Taking Risks: The Management of Uncertainty.* New York: Free Press

MacCormack, A., Verganti, R., & Iansiti, M. (2001). Developing products on Internet Time: The anatomy of a flexible development process. *Management Science*, 47(1), 133–150.

Mandal, S., Moudgil, M., & Mandal, S. K. (2009). Rational drug design. *European Journal of Pharmacology*, 625(1–3), 90-100.

March, J. G., & Simon, H. A. (1958). *Organizations*. New York: Wiley.

Maturana, H. R., & Varela, F. (1980). *Autopoiesis and Cognition: The Realization of the Living.* Dordrecht: Reidel.

Maunsell, J. H. R. (1995). The brain's visual world: representing visual targets in cerebral cortex. *Science*, 270(5237), 764-769.

Mayr, E (2000). Biology in the twenty-first century. *BioScience*, 50(10), 895–897.

McCombs, M. E. & Shaw, D. L. (1993). The evolution of agenda-setting research: Twenty-five years in the marketplace of ideas. *Journal of Communication*, 43(2), 58-67.

Meyer, J. W., & Rowan, B. (1977). Institutionalized organizations: Formal structure as myth and ceremony. *American journal of sociology*, 83(2)340-363.

Miller, A. I. (2009). *Deciphering the Cosmic Number*. New York: Norton.

Mitcham, C. (1994). *Thinking Through Technology.* Chicago: University of Chicago Press.

Müller, R., Andersen, E. S., Kvalnes, Ø., Shao, J., Sankaran, S., Rodney Turner, J., Biesenthal, C., Walker, D. and Gudergan, S. (2013), The Interrelationship of Governance, Trust, and Ethics in Temporary Organizations. *Project Management Journal*, 44(4), 26–44.

Nelson, R.R., & Winter, S.G. (1982). *An Evolutionary Theory of Economic Change*. Cambridge, Massachusetts: The Belknap Press of Harvard University Press.

Nicholls, M.K. (1999). The influences of eastern thought on Schopenhauer's doctrine of the Thing-in-Itself. In C Janaway (ed.): *The Cambridge Companion to Schopenhauer*. Cambridge, UK: Cambridge University Press, 171-212.

Nicolini, D., Mengis, J., & Swan, J. (2012). Understanding the role of objects in cross-disciplinary collaboration. *Organization Science*, 23(3), 612–629.

Nightingale, P. (1998). A cognitive model of innovation. *Research Policy*, 27(7), 689-709.

Nightingale, P. & Martin, P. (2004). The myth of the biotech revolution. *Trends in Biotechnology*, 22(11), 564-569.

Noble, D. (2010). Biophysics and systems biology. *Philosophical Transactions: Mathematical, Physical and Engineering Sciences*, 368(1914), 1125-1139.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization science*, 5(1), 14-37.

Orlikowski, W. J. (2007). Sociomaterial practices: Exploring technology at work. *Organization studies*, 28(9), 1435-1448.

Parsons, T. (1960). *Structure and Process in Modern Societies*. New York: The Free Press of Glencoe.

Perrow, C. (1984). *Normal Accidents: Living with High-Risk Technologies*. New York: Basic Books.

Pickering, A. (1981). The hunting of the quark. *Isis*, 72(2), 216-236.

Pinker, S. (1999). How the Mind Works. *Annals of the New York Academy of Sciences*, 882(1), 119–127.

Poincaré, H. (1912). Pourquoi l'espace a trois dimensions. *Revue de Métaphysique et de Morale*, 20(4), 483-504.

Polanyi, M. (1966). *The Tacit Dimension*. Garden City, NY: Doubleday.

Prigogine, I. (1997). *The End of Certainty*. New York: Free Press.

Quine, W. V. (1951). Two dogmas of empiricism. *Philosophical Review*, 60(1), 20-43.

Rashevsky N. (1935). The biophysics of space and time. *Philosophy of Science*, 2(1), 73-85.

Rosch, E. (1978). Principles of categorization. In *Cognition and Categorization*, E. Rosch and B. B. Loyd (eds.), 27-48. Hillsdale, NJ: Lawrence Erlbaum.

Sapolsky, H. (1972). *The Polaris System Development: Bureaucratic and Programmatic Success in Government.* Cambridge, Mass.: Harvard University Press.

Sauer, U., Heinemann, M., & Zamboni N. (2007). Getting closer to the whole picture. *Science*, 316 (5824), 550-551.

Scarbrough, H., Panourgias N. S. & Nandhakumar, J. (2015). Developing a relational view of the organizing role of objects: A study of the innovation process in computer games. *Organization Studies*, 36(2), 197-220.

Schein, E. H. (1985). *Organizational Culture and Leadership.* San Francisco: Jossey-Bass.

Schopenhauer, A. (1966). *The World as Will and Representation. Volume I.* Translated by E. F. J. Payne. New York: Dover Publications.

Schwaber, K. (1997). Scrum development process. In D.J. Sutherland et al. (eds.) *Business Object Design and Implementation* (p. 117-134). London: Springer.

Shapira, Z. (1995) *Risk Taking: A Managerial Perspective.* New York: Russel Sage Foundation.

Shenhar, A. J. (2001). One size does not fit all projects: Exploring classical contingency domains. *Management Science*, 47(3), 395–414.

Shneiderman, B. (1979). Human factors experiments in designing interactive systems. *Computer*, 12, 9-19.

Simon, H. A. (1978). Rationality as Process and Product of Thought. *Journal of American Economic Association*, 68(2), 1-16.

Simon, H. A. (1981). *The Sciences of the Artificial* (2nd ed.). Cambridge, MA: MIT Press.

Simpson, B. (2009). Pragmatism, Mead and the practice turn. *Organization Studies*, 30(12), 1329-1347.

Sommer, S. C., & Loch, C. H. (2004). Selectionism and learning in projects with complexity and unforeseeable uncertainty. *Management science*, 50(10), 1334-1347.

Star, S. L., & Griesemer, J. R. (1989). Institutional ecology, 'translations' and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social Studies of Science*, 19(3), 387-420.

Stinchcombe, A. (1990). *Information and Organizations*. Berkeley: University of California Press.

Storbeck, J. & Clore, G. L. (2007). On the interdependence of cognition and emotion. *Cognition & Emotion*, 21(6), 1212-1237.

Suddaby, R., & Greenwood, R. (2005). Rhetorical strategies of legitimacy. *Administrative science quarterly*, 50(1), 35-67.

Taleb, N. N. (2007). Black swans and the domains of statistics. *American Statistician*, 61(3),198-200.

Tegarden, D. P., Sheetz, S. D., & Monarchi, D. E. (1995). A software complexity model of object-oriented systems. *Decision Support Systems*, 13(3-4), 241–262.

Tooby, J., & Cosmides, L. (1992). The psychological foundations of culture. In J. H. Barkow, L. Cosmides, & J. Tooby (Eds.), *The Adapted Mind: Evolutionary Psychology and the Generation of Culture.* (pp. 19–136). New York: Oxford University Press.

Tsoukas, H., & Chia, R. (2002). On organizational becoming: Rethinking organizational change. *Organization Science*, 13(5), 567-582.

Tverski, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, 185(4157), 1124-1131.

Van de Ven, A. H., & Poole, M. S. (1995). Explaining development and change in organizations. *Academy of management review*, 20(3), 510-540.

Vincenti, W. G. (1990). *What engineers know and how they know it*. Baltimore: John Hopkins UP.

Visser, W. (2006). Designing as construction of representations: A dynamic viewpoint of cognitive design research. *Human-Computer Interactions*, 21(1), 103-152.

Weick, K. E. (1979). *The Social Psychology of Organizing (2nd ed.)* Reading, Mass.: Addison-Wessley.

Weick, K. E., Sutcliffe, K. M., & Obstfeld, D. (2005). Organizing and the process of sensemaking. *Organization science*, 16(4), 409-421.

Wertheimer, M. (1938). Gestalt Theory. In *A Source Book of Gestalt Psychology*, Ellis, W. D. (ed.), 1-11. London: Routhledge & Kegan Paul.

White, R. (2010). Schopenhauer and Indian Philosophy. *International Philosophical Quarterly*, 50(1), 57-76.

Whitty, S. J., & Maylor, H. (2009). And then came complex project management (revised). *International Journal of Project Management*, 27(3), 304-310.

Williams, T. M. (1999). The need for new paradigms for complex projects. *International Journal of Project Management*, 17(5), 269-273.

Williamson, G.S. (2004). *The longing for myth in Germany*. Chicago: University of Chicago.

Williamson, O. E. (1981). The economics of organization: The transaction cost approach. *American Journal of Sociology*, 87(3), 548–577.

Wimsatt, W. C. (2006). Aggregate, composed, and evolved systems: Reductionistic heuristics as means to more holistic theories. *Biology & Philosophy*, 21(5), 667–702.

Winch, G. (1989). The construction firm and the construction project: A transaction cost approach. *Construction Management & Economics*, 7(4), 331-345.

Wittgenstein, L. (1953). *Philosophical Investigations.* Oxford: Basil Blackwell.

Zajonc, R. B. (1984). On the primacy of affect. *American Psychologist*, 39(2), 117-123.

Zaltman, G., & Coulter, R. (1995). Seeing the voice of the customer: Metaphor-based advertising research. *Journal of Advertising Research*, 35(4), 35-51.

Zasso, A. (1996). Flutter derivatives: Advantages of a new representation convention. *Journal of Wind Engineering and Industrial Aerodynamics*, 60(1), 35-47.

Zeki, S. (1992). The visual image in mind and brain. *Scientific American*, 267(3), 42-50.