Creativity and Risk Taking Aren’t Rational:  
Behavioral Operations in MOT

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Abstract

Behavioral Operations Management explicitly considers the effects of human behavior in process performance, influenced by cognitive biases, social preferences, and cultural norms. This broadening of Operations is even more critical in the context of the Management of Technology (MOT) than in the operations of established ongoing processes, because in innovation, people do not know well which tasks they will have to perform, they are exposed to risks, and they are subject to emergent interdependencies, all of which push psychological biases and social preferences to the fore.

This article gives an overview of important behavioral challenges in MOT, setting them in the context of the phases of the stage gate process on the one hand, and the three levels of individual biases, group member interactions, and large group interactions (e.g., culture) on the other hand. The review suggests that previous work has not addressed a number of important questions in empirical effects and theoretical underpinnings, gaps that are very important for the performance of organizations in practice. The article concludes by offering opportunities for high-impact future work.

Keywords: Behavioral Operations, Innovation Process, New Product Development, Project Management, Decision Biases, Emotions.

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1. Introduction

The field of Operations Management (OM) "encompasses the design and management of the transformation processes in manufacturing and service organizations that create value for society (...) the search for rigorous laws governing the behaviors of physical systems and organizations" (Chopra et al. 2004: 8). However, the traditional approach to Operations has been limited in the sense that "Operations management models have historically invoked oversimplified models of motivation, learning, creativity, and other such aspects of human behavior that are vital to the success of management policies in practice" (ibid: 13).

Just as "Increasing the realism of psychological underpinnings of economic analysis will improve economics on its own terms—generating theoretical insights, making better predictions of field phenomena, and suggesting better policy" (Camerer and Loewenstein 2003), Behavioral Operations adds to the traditional systems-focused view of Operations Management, "explicitly considering the effects of human behavior in process performance, influenced by cognitive biases, social preferences, and cultural norms" (Loch and Wu 2007: 15).

This addition is even more critical in the context of the Management of Technology (MOT) than in the operations of established ongoing processes. In an established process, a known recipe is executed (efficiently and reliably), so success drivers are understood, performance can be measured by well-defined indicators, and interactions among various agents in the process are known, so they can be incorporated into action recipes and contingent scripts. Narrow "economic rationality" and economic incentives can explain a larger fraction of observed behavior (although even here behavioral issues play a large role). In contrast, MOT is concerned with "designing and implementing business innovations leading to the successful launch of new products and services, new production and service creation processes, changes in the basic structure of extended supply chains, and changes in the delivery channels" (Gaimon, introduction to this special issue). In the creation of innovations, the recipes are not known beforehand, therefore the success drivers and interactions among actors are not known in the activities that are carried out in the MOT context. Moreover, the actors are exposed to uncertainty (not only risk but indeed Knightian uncertainty) and to mutual dependencies among themselves, causing tensions that cannot be sufficiently addressed by processes and action scripts. Therefore, emotions and psychological "shortcuts" (biases) influence the actors' behavior even more strongly than in routine processes.

Indeed, it was the frequent observation of patterns of systematic behavior deviations from economic rationality in new product development and innovation activities in firms, which motivated me to start studying evolutionary psychology and behavioral economics in the mid 1990s. Twenty years of research in this field (which did not have a name when I started) have given structure and depth to these initial observations. In this article, I will attempt to identify a meaningful structure of key behavioral aspects in MOT challenges, and describe research opportunities. Section 2 gives a qualitative framework of innovation process steps; in each of the innovation steps, behavioral issues arise at three levels (individual biases, group interactions, and organizational identity and culture). Section 3 then describes the behavioral issues in more detail. Section 4 concludes with some research opportunities.
2. A Process Framework for Behavioral Issues in MOT

2.1. The Stage Gate Process

In order to discuss the behavioral management challenges involved in MOT activities, let us consider them in the context of the “innovation process”. Figure 1 summarizes the typical structure of a generic innovation process (reflecting the stage gate process philosophy). Innovation activities happen in the context of the organization’s strategy (being guided by strategy and, at the same time, influencing the strategy by identifying barriers or creating new opportunities). Three fundamental steps of innovation are observable in all evolutionary changing systems (Campbell 1960): the creation of new opportunities or ideas, which is at least partially “random” because not enough information is available to guide novel opportunities; the selection of some of these ideas according to consistent criteria, for example, “fitness” in biological evolution, and “attractiveness” or “strategic fit” in organizations; and finally, the execution of the ideas, their elaboration, modification and implementation in offspring (evolution), artifacts, services and solutions that are thrown into the world or into the market.

![Figure 1: A Generic Stage-Gate New Product and Process Development Process](image)

The term "process" suggests that these innovation activities can be programmed and standardized, but this is the case only in a limited sense: For example, there are “tools” for idea creation (such as structured idea creation techniques in engineering, brainstorming, "best idea tournaments", etc.), but how to mobilize an organization of production and knowledge workers, as well as the external supplier and partners of the organization, to offer their best secret ideas, and recognize and seriously consider (but not simply accept) them, cannot be fully programmed in the form of process rules. Mobilizing an organization’s creativity is a difficult managerial challenge that requires some rules but must be accompanied by a culture of certain behaviors and by (emotionally driven) identification with and trust in organizational role models and groups, in order to yield significant results.

In the same way, selecting innovation opportunities can be supported by process tools (for example, through formal criteria such as NPV, strategic fit, risk balance, or market...
potential, and through formal top-down and then bottom-up coordination rounds), but tools are helpful only if they build on and are guided by a shared vision of the strategic goals (for example, the desired market position, the technology profile, the face to the customer). Formal processes alone will inevitably produce diverging subgroups, and decisions in those subgroups, over time. Behavioral issues play, again, a large role because decision makers tend to be myopic (both in time and in the range of consequences of their actions that they spontaneously consider) and influenced by their social preferences and interactions among group members.

The “execution” activities (from funded concept to launch) in the stage gate process of Figure 1 involve two fundamental challenges, the management of uncertainty and of stakeholders. Indeed, the stage gate process allows for moderate uncertainty but assumes in its very structure (of sequential plannable activities, in spite of allowing for a bit of iteration as represented by the arrows in Figure 1) that most of the uncertainty can be eliminated by the planning and selection at the outset. Therefore, the stage gate process is limited in its ability to respond to the Knightian or “unforeseeable” uncertainty that inevitably comes with highly novel innovations (both in in products and processes). A large body of work has shown that for highly novel innovation, more experimentation and iteration are required, and several candidate solutions may have to be carried forward for longer and selected when performance emerges, not based on initial planning decisions (Leonard Barton 1995, Loch et al. 2006, Sommer et al. 2009, Lenfle and Loch 2010).

Uncertainty is a fundamental challenge for human psychology, which exhibits mental shortcuts (such as loss aversion) and myopia (possibly leading to time reversal of preferences) as well as inhibitions caused by interactions with other group members. These psychological issues are exacerbated by the managerial craving for control, which sometimes makes lip service such as “we welcome failures to learn from them” hollow, thus preventing radical innovations that require parallel trials and experimentation, from going ahead.

The “stakeholder” issue refers to the fact that innovation initiatives, just like any change initiative, are not decided and accepted in an organization based on purely rational criteria (as I mentioned earlier), but need the support of those people who are touched by and can influence the initiative, and decide to do so positively or negatively. Stakeholders have objectives that they want to achieve, and an innovation initiative may support such objectives or stand in the way. However, stakeholder reactions are not just the result of a rational maximization of a multidimensional choice problem, but they are also emotional, influenced by, for example, relationships (“what do my friends say?”), by their own feeling of importance (“have they acknowledged and respected me?”), and by organizational protocol (“one just doesn’t pursue something like this here in this place without first consulting committee XYZ”).

The final issue shown in Figure 1 is pervasively important in innovation, namely working with contractors and partners as more and more innovation is “open” and “outsourced”. Economics and Operations Management have produced a literature on contracting, which treats the issue as a principal-agency problem where the right incentives need to be set under incomplete information about the capabilities and goals of the partners. But there is ample evidence that effective working with partners cannot be achieved with rational contracts alone, several key behavioral issues must be addressed as well.

2.2. Behavioral Issues in the Stage Gate Process
The stage gate process of innovation management hides “behavioral” issues in every
step, meaning that decisions and actions are chosen not only according to rational logic, not even rational logic in which various actors have non-aligned interests, but the actors’ decisions are driven by psychological shortcuts, by emotional forces related to group interactions, and/or by cultural norms that follow their own dynamics, possibly disconnected from the decision goals in the specific case.

Table 1 gives an overview of important behavioral issues in the context of the innovation process. The left-hand column of Table 1 represents the stage gate process steps from Figure 1, from creativity to contract management. The first row of Table 1 introduces three types of behavioral issues, which differ by the level at which they operate. The first issue refers to individual "decision biases", which reflect the fact that human psychology has not evolved as a "general purpose computer" but is a collection of "domain specific problem solving devices" that operate semi-autonomously and are not always appropriate or sufficient for the uncertain or long-term decision problems faced by managers (Cosmides 1989).

**Table 1**: Managerial Challenges and Behavioral Phenomena in Innovation Processes

<table>
<thead>
<tr>
<th>Innovation Process Step</th>
<th>Reference Group in Behavioral Issue</th>
<th>Individual Biases</th>
<th>Group Interactions: small groups</th>
<th>Group interactions: large groups, and culture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idea generation (and the creativity of this step)</td>
<td>Individual Biases</td>
<td>Overconfidence, framing and confirmation bias (limiting the motivation for experimentation)</td>
<td>Limits of brainstorming: biases (e.g., evaluation apprehension, imitation, opinion &quot;clusters&quot;) and status differences can suppress group creativity</td>
<td>“Established” ways of thinking Behavioral markers signify in- and outgroups, triggering identification or rejection</td>
</tr>
<tr>
<td>Selection in the strategic context; “cascading” (translating aggregate goals into operational actions)</td>
<td>Group Interactions: small groups</td>
<td>Myopia Bounded rationality</td>
<td>Identification with overarching goals, trust, and relationships</td>
<td>Cultural inertia (“aesthetics”) on how things are done</td>
</tr>
<tr>
<td>Execution: Technical and market risk, uncertainty</td>
<td>Group Interactions: large groups, and culture</td>
<td>Loss aversion</td>
<td>Psychological safety</td>
<td>Imitation (the role of mentors)</td>
</tr>
<tr>
<td>Execution: Stakeholder risk and uncertainty (networks and relationships)</td>
<td>Group Interactions: large groups, and culture</td>
<td>Time-variable risk aversion (e.g., under stress)</td>
<td>(Emotional) relationships (between protagonist and stakeholders, and among stakeholders)</td>
<td>What constitutes respect and relationships</td>
</tr>
<tr>
<td>Execution: Contracts (working with contractors and partners)</td>
<td>Group Interactions: large groups, and culture</td>
<td>Short termism (myopia) Bounded rationality</td>
<td>Flexible contracts and relationships</td>
<td>Cultural differences impede communication and understanding</td>
</tr>
</tbody>
</table>

The second behavioral issue refers to the interactions in small groups, which emotionally affect decisions in systematic ways. A large body of evidence exists that people do not only evaluate decisions with respect to their personal goals, but also with
respect to social preferences (Loch, Galunic and Schneider 2006), including their standing in relevant groups, for example, relative outcomes and status (who does better than whom, who has a higher status), relationships (who owes what to whom and who supports whom), and group identity (what is the fate of this group versus other salient groups).

The third behavioral issue refers to the effect that large group norms, aesthetics and rules have on decisions. As people are bounded in their ability to comprehend the world, organizations function by following culture. This refers to the socially learned routines and assumptions of social integration and problem solving that successive generations of a group’s members inherit (Schein 2004, Boyd and Richerson 2005). Cultural “routines” store essential information about what the organization is doing and how people coordinate, and much of the knowledge that underlies effective performance is tacit knowledge of the organization, not consciously known and/or hard to articulate by anyone in particular (Nelson and Winter 1982: 134). People make decisions based on “aesthetic judgments” and on internalized routines, in ways that they cannot necessarily explain.

The entries in the cells of Table 1 give “headlines” of important behavioral phenomena in innovation. I call these “important” because they influence decision making in innovation not only “a bit on the margin” but substantially, to the degree that if one looked at innovation through a lens of “rational optimization” only, one would not be able to make sense of what one sees in most organizations. The remainder of this article expands on these headlines. I will attempt to give an example for why these phenomena are important, and list some evidence (previous studies) for each phenomenon.

Due to space constraints, this article will not discuss “high performance teams” (an important enabler of successful innovation projects), including both the skill mix that “covers” the tasks and (emotional) group dynamics, as a rich literature exists in the field of Organizational Behavior.

2.3. “Radical” Versus “Incremental” Innovation

The stage gate process of innovation was developed in the 1960s in the United States, in order to establish “control” over the unlimited-budget all-out breakthrough military projects from the 1940s and 1950s: The Manhattan, Polaris and Trident projects were great successes, but the “MacNamara revolution” aimed to reduce the risks of such projects and increase “efficiency” (Lenfle and Loch 2010). The philosophy of the stage gate process is to frontload the innovation with problem-solving and analysis, reducing uncertainty to the point where resources can be efficiently brought to bear. Thus, by design, the stage gate process is appropriate for moderate innovations (such as the “next generation” car or software or computer), which are large and significant enough to warrant a “process”, but on which the organization possesses enough knowledge that planning can be successful.

The stage gate process is too “heavy-handed” for small “continuous improvement” innovations, for example, six-sigma and quality circle projects, and for “incremental” small product changes. The former build on ideas volunteered by workers (bottom-up creativity), are chosen based on the clarity and attractiveness of the improvements they offer, and pose only little uncertainty and complexity, therefore needing only informal project management. Small product changes are more formal than continuous improvement, being often driven by customer complaints and marketing analyses, but they also pose low uncertainty and can be handled in simplified processes. In both these types of initiatives, the behavioral issues therefore lie in team spirit (group identity and
relationships) and motivation. Workers are motivated to contribute not by bonuses but by acknowledgement and recognition, and by the feeling of having an influence.

On the other hand, the stage gate process is too rigid to effectively deal with the high uncertainty of "radical" innovation. "Radical" here refers to a large feature/performance change in the product or the customer interaction. This means high uncertainty (as any large change means less is known about how well the aimed-for solution will work, either from the technical or from the customer side). It also means complexity, as a large performance change often requires changes across product hardware, as well as manufacturing, service delivery and sales processes (Wheelwright and Clark 1992). Managing a radical innovation with high uncertainty requires more flexible approaches, including iteration and even parallel trials, which the stage gate process, in its very design striving for control, has difficulties in accommodating (Sommer et al. 2009).

In a radical innovation project, all behavioral challenges are amplified: ideas need to come from multiple sources (often from unusual suspects or the outside), project prioritization requires more judgment because the "numbers" (the formal criteria) are less well applicable and estimated, uncertainty is higher and scarier, and interdependence across multiple parties increases, requiring more parties to negotiate a way forward. In many organizational innovations, the negotiations among multiple stakeholders with different views and status positions are often anything but rational and can become the most difficult management challenge (Loch 2016, Loch et al. 2016).

The more detailed discussion of the behavioral challenges in Section 3 does not specifically discuss the differences between incremental, moderate and radical innovation projects. The discussion will be "roughly" based on the stage gate process (moderate innovation), and the reader should keep in mind that behavioral issues of selection, uncertainty and execution are exacerbated in radical innovation projects. Nor will I be able to provide a full literature review; I will list a few striking studies for each phenomenon (apologizing here to all authors who have written additional relevant studies on the topics, which I neglect) --- my emphasis is on the phenomena that represent important questions and opportunities for additional MOT research.

3. Behavioral Phenomena in MOT and Research Opportunities

I will now discuss important behavioral issues in innovation processes, following the steps of the stage gate process (Figure 1), at the three levels as introduced in Table 1. The theme of this section is that behavioral issues are not merely small modifications of a largely rational process, but cause substantial changes in how innovation processes unfold.

3.1. The Creativity of the Idea Generation Process
Creativity is similar in its meaning to innovation--it can be defined as the production of something novel that is useful (Simonton 1999), where "useful" refers to the solution of some kind of problem. A creative process, or the generation of new ideas for problem solutions, can be seen as selective heuristic search in a domain, and careful examination of the new phenomena disclosed by this search, based on deep domain expertise (Simon 2001: 214). In a search process, variance is a source of value--it is better to search broadly generating 99 bad ideas and one brilliant one than to search in a narrow and controlled way generating 100 solid average ideas (Girotra et al. 2010). In creating many ideas in innovation search, "diversity (among the searchers) trumps talent (of the searchers)" (Hong and Page 2004).

This feature of search processes is directly visible in many studies of the organizational
capability to effectively generate new ideas as input in the innovation process. For example, a classic result from the Minnesota studies of innovation (Van de Ven 1986) suggests that organizations are creative if they involve many people, let them communicate and decentralize the loci of finding sources (at least for the early explorations that can be done with little funds), in order to maximize the number and diversity of ideas considered. Wuchty et al. (2007) and Singh and Fleming (2010) showed that patent inventors are more productive if they work with others and are embedded in networks, thus being more exposed to varying ideas from multiple sources. Loch et al. (2010) demonstrated how in the creation of a new manufacturing system, the involvement of experts from different domains (including workers, engineers, unions, external ergonomists) contributed to the creation of a new way of running manufacturing lines. Systematic network studies have shown that having many weak ties (less frequent interactions, less influential) offers an actor more diversity and thus more creativity than strong ties, but that creativity suffers when people also have many external ties—they become “overwhelmed” by all influences (Perry-Smith 2006).

However, the creative process of generating novel ideas is not a cold rational process, rather, it is heavily influenced by decision biases and emotions. At the individual level, people tend to exhibit a “confirmation bias”; they seek confirmation of starting hypotheses rather than looking for novel ideas that disconfirm their starting point (this was experimentally shown in 1960 in Peter Wason’s famous “2-4-6 task”), which of course limits their ability to generate new ideas. Creative individuals tend to be those who are open to varied and diverse experiences and capable of defocused attention on many things, enabling them to generate more diverse “starting points” (Simonton 1999, 86-92).

Moreover, the creative search effort that people bring to bear is not necessarily enhanced by economic incentives. It had long been shown in psychology that piece rate incentives (for the number of ideas offered) “crowds out” creativity (Amabile 1982). In addition, an experimental paper has demonstrated that subjecting people to competition during the creative process may reduce creativity even more (Erat and Gneezy 2015). There is considerable debate on this in the creativity literature. A recent meta-study suggests that rewards in themselves may not crowd out creativity, but that it is their use as control devices (incentivizing outcomes) that suppresses creativity, whereas giving more positive, contingent, and task-focused performance feedback and more choice can enhance creativity (Byron and Khazanchi 2012; see also Shalley and Perry-Smith 2001).

This brings us to the group level, where interactions among creative searchers have a heavy influence. A very popular “creativity technique” for groups is brainstorming, or the creation of problem solution ideas in groups, following four rules (Osborn 1953): create as many ideas as possible, force yourself to create “wild” ideas (i.e., different from the status quo), do not criticize ideas, and combine and improve upon the ones proposed. It seems intuitive that people building on one another’s ideas should help creativity, however, studies have shown that brainstorming suffers a “productivity loss” as compared to people generating their ideas in isolation, due to “production blocking” (only one person can speak at a given time, so ideas might be forgotten while listening to others), “evaluation apprehension” (group members may not express some ideas because of their “reputation” in the group) and free-riding on others (compared with working alone, individuals in groups do not feel as accountable for producing ideas, so they devote less effort) (Sutton and Hargadon 1996). Only if the group is solving a cross-functional problem that requires wider expertise than any individual possesses will the mutual learning benefits from interaction overwhelm the interactional blockage (Sutton and Hargadon 1996, Kavadias and Sommer 2009), otherwise group members
easily hinder one another more than helping in creative search because of social pressure.

In discussions of creativity and diversity of idea creation, the impression sometimes arises that ideas are “born” being good or bad (and then selection weeds out the bad ones). But ideas are born imperfect and (usually) not working, they become “good” (if at all) by evolving and changing. Therefore, collaborative interactions among team members are important not only for idea generation, but also fundamentally for the process of evolving the ideas. This goes against the well-known tendency of engineers to resist sharing “half baked” ideas (Terwiesch and Loch 2002), but in fact, most ideas are half-baked and in need of development, and experienced managers of creative processes choose teams (for their ability to evolve ideas) rather than ideas themselves (Catmull 2014: 75; this is also consistent with observations of the startups in the accelerator at my business school, where initial ideas never work, but the teams that evolve the half baked ideas are the force behind success).

Finally, the creative behavior of individuals is heavily influenced by the cultural routines of the organization, which include unspoken “aesthetic” judgments. This includes aesthetic taste in the literal sense: for example, I have seen interior designers in one car company value and produce a beauty of simple (and cost-effective) designs, while the equivalent designers in a high-end car company valued a different kind of beauty from luxurious materials and plushness. Such judgments are not made case-by-case but express internalized “values”, and indeed, the two companies cannot easily get on each other’s territory because they do not know how to design the respective other type of car well.

In this context creativity is supported or suppressed by cultural routines such as “tolerance of failure” (a widely cited principle, which few companies are able to actually put in practice because it is perceived to contradict “accountability”). An important cultural influence comes from role models (Gemünden et al. 2007): often, individuals internalize cultural routines via imitation of others who are seen as positive examples. Once an organization has people who became successful by producing creative ideas, others will change their behavior beyond the minimal requirements of explicit processes. When creative co-workers are present in the organization, workers are willing to behave more creatively, and are motivated to do so especially when supervision is reduced (Zhou 2003). Again, the creative process is not cold and rational but subject to the emotions of personal interactions and cultural internalization.

3.2. Selection in the Strategic Context
Conceptually, innovation needs to support the business strategy of the organization and so the innovation goals need to be “cascaded” down from strategy (Roussel et al. 1993). This description is of course too simplistic because top management does not know what either the best innovation opportunities or the best exploration actions are, so strategy is not only made at the top and then cascaded, but also made at the operational level and then cascaded up to modify the strategic priorities (Burgelman 1983, Kim et al. 2014). In short, the selection and execution of innovation ideas in the organization’s innovation program form part of an integrated strategic-operational system.

This system is strongly limited by bounded rationality: top management does not understand the technical issues in invention and innovation or development, and the technical staff do not (or not fully) understand the strategy. Indeed, these two groups speak different languages—innovation staff a technical language of customer requirements and technical solutions, while top management speaks in terms of financial returns and market shares. As a result, lower-level pre-selection of ideas is
often not aligned with the higher-level prioritization direction that senior management may have in mind. In addition, the functional groups involved also speak different languages, for example, Marketing speaks in terms of customer needs and R&D personnel uses a language of technical functionalities. The same term may mean different things in these two languages, for example, “high quality” in Marketing refers to a user perception that can be influenced by the sales process, whereas “high quality” in R&D language usually refers to precise technical parameters. The misunderstandings that result from an unawareness and/or lacking “translation” between the languages top-down or laterally can easily lead to misdirected resources, or even to failed innovation projects (this has long been known in Organizational Behavior, e.g., Dougherty 1992).

In addition to bounded rationality, the complex process of the innovation portfolio selection is subject to behavioral issues at all three levels shown in Table 1. At the individual level, short-termism (myopia) is wide spread (Sayman and Öncüler 2009). When individuals see the cost of an effort in the context of an R&D project as immediate and salient, while benefits of actions come in the future, then procrastination will result with “back-loading” of effort into later project stages; this, in turn undermines project planning and causes a non-anticipated accumulation of problems later, in the implementation phase, of projects (Wu et al. 2015).

Of course, the opposite phenomenon is the “iron law of megaprojects” (Flyvbjerg 2007, 2014), which observes that most large complex multi-stakeholder projects overpromise outcomes and schedules but then under-deliver due to overconfidence in the planning of large projects. It is however, not clear whether this is indeed a behavioral issue (overconfidence), or a “rational” response of the planners to the prevailing incentives: Already Mansfield (1972) observed in an empirical study that projects that are close to the minimum cut-off performance typically overpromise in the selection meetings (in order to make it into the chosen set of activities), while highly attractive projects which are certain to be chosen under-promise (in order to then be able to over-deliver on their numbers). If an organization’s (or government agency’s) incentives are structured such that the project proposer needs to document performance above a cutoff rate, then not only “great” projects but also ones with “massaged” numbers above this cutoff rate is what the organization will get as a rational response of the proposers.

Another piece of evidence for widespread biases in project selection can be found in Sting and Schlickel (2015), who examined the initially estimated versus later achieved cost savings of continuous improvement projects in an automotive manufacturer. They find that the proposers of process improvement ideas systematically overvalue their value, and moreover, the level of over-optimism increases with the organizational rank of the proposer, and it is also greater when a team proposes an idea rather than an individual. This evidence is again ambiguous---it may be rational to oversell one’s ideas, and a highly ranked creator may have more at stake, and thus a greater incentive to exaggerate. This needs more and deeper research, but I think it is fair to say that evidence is accumulating for systematic psychological biases deviating from pure economic rationality (for example, this study is consistent with project overestimation being influenced by status seeking and hubris).

At the level of group interactions, it is sensitive and difficult to examine the interactions within senior management teams that determine the innovation portfolio of an organization. All operations based texts on portfolio selection are normative in outlining what good decision processes should look like (the best know examples are Wheelwright and Clark 1992, Roussel et al. 1991, Cooper at al. 1999).
organizational theory literature is also normative in outlining what good interactions among the managers on the on portfolio selection team should look like, for example, that they should establish common goals and have open debates considering multiple alternatives (Eisenhardt et al. 1997).

But the group interactions within project selection teams are not always constructive because emotional forces such as defending one's status, or safeguarding a relationship, or preserving the integrity of the group may distort the decision process, leading, for example, to keeping unattractive projects in in order to not admit a past mistake, or keeping inconvenient projects out that may be against some group members' interests. It is one thing to say such interactions among group members should not happen, but they do happen, and, to my knowledge, no research exists on how interactions in a senior management group evolve and how they might be shaped to be constructive. I have an abundance of anecdotal evidence that management groups do not perform project selection well, because of interactions among group members, and I give one example. A company wanted to improve its innovation project selection process for its senior management team. They discussed introducing a scoring procedure, where projects are given “points” for performing high on certain criteria (such as return, or risk, or "strategic fit", etc.), and the highest scoring projects are chosen. I advised against such a procedure because it was mechanical and would produce (likely simplistic) "black-box" answers without facilitating a discussion that would contribute to a shared view of the management team. But I was told ("off the record") that the members of the management team wanted a “mechanistic” answer rather than a discussion—a black-box answer would achieve decisions without any of the management team members having to risk “losing” an argument and thus having their status and reputation exposed. While this sounds clearly dysfunctional, it is according to my experience not an exception. And yet, I know of no research that diagnoses how widespread such social-preference-driven interactions are, or examines how management teams might be convinced to adopt more sophisticated (but also more demanding) decision methods in project selection.

3.3. Risk and Uncertainty

The very nature of innovation, namely the execution of novel activities, implies that the innovators are facing risk (multiple possible outcomes according to a known probability distribution), uncertainty (multiple outcomes without a know probability distribution, sometimes also referred to as ambiguity) or even unknown unknowns (outcomes that one cannot describe at the outset). Risk and uncertainty are associated with many behavioral issues—as our human (and before that non-human) ancestors continuously faced both challenges, human psychology is riddled with behavioral algorithms that help us to respond to risks better than our unaided intelligence.

In general, people do not like risk and like ambiguity even less. But how do we account for risk aversion? Investors use “risk premia” in the form of costs associated with the “beta” of investments. But is this the right decision criterion? Some managers explicitly use a different criterion in choosing projects, namely the “max min” criterion, or the project with the least threatening worst case, eliminating the left tail of the outcome distribution (in project management, this is referred to as “ensuring a floor”)—this criterion better reflects how some people would like to protect themselves. Under which circumstances should we use which decision criteria? To my knowledge, this question has not been well answered by research to date.

Moreover, risk premia assume that risk aversion is constant (over time for a given individual, although individuals differ). But there is ample evidence that this is not the case. First, people’s risk aversion depends on how competent they feel in the decision
area---when they feel expert, they may actually seek out more risk or ambiguity (Karelaia and Hogarth 2010). Second, risk aversion waxes and wanes with people’s perception of stress---when subjects are subjected to volatility, their cortisol levels increase, which in turn suppresses their risk appetite (Kandasamy et al. 2014). This is so systemic that it may pro-cyclically contribute to financial market bubbles---as risk perception shrink, traders will take more risk and inflate the bubble, whereas the volatility of a market crash reduces their risk appetite to the point that it may contribute to financial institutions starving the economy of loans (Coates 2015).

While risk aversion waxes and wanes in this way, it usually influences people’s actions strongly: they often act in ways that may allow them to avoid the risk, or hide the “deviations from the plan” caused by it. A well known condition for workers to be willing to engage in risk and to admit deviations (or “errors”) is the provision of “psychological safety”, or a worker having the feeling of being able to show her self without fear of negative consequences to self-image, status, or career. Sting et al. (2015) document how providing psychological safety (by offering help to project engineers when they alerted management to problems) significantly helped a product development organization to identify problems earlier (front-loading them), therefore making them faster and cheaper to resolve, and thus speeding up development projects.

Siemsen et al. (2009) showed that psychological safety influences knowledge sharing even more widely, an activity that is crucial in innovation projects where new knowledge arises and needs to be made available to all participating employees. The study finds that workers share their knowledge reliably only if they are provided with psychological safety; only if they are very confident of their knowledge (and thus not afraid of mistakes or other vulnerabilities) do they share independent of the environment. Also, management attitudes to knowledge change: if the manager, in the uncertain context of an innovation, is held to a target, s/he will invest less in building the workers’ knowledge than if there is an upside (a threshold incentive) (Carillo and Gaimon 2004).

People may not only avoid risk, but also refuse to change their views when changes in the project’s situation have in fact occurred. A whole literature on escalation of commitment has demonstrated that project workers often stick to decisions that they made at the outset, although it is clear that these decisions are now obsolete (Ross and Staw 1981, Boulding et al. 1997).

Risk and uncertainty are deeply disliked not only by project workers but also, possibly even more so, by managers: unforeseen events make it hard to plan and control, making accountability and performance management more difficult. This has affected an entire management discipline, namely project management: although the great weaponry projects of the 1950s (the nuclear bomb, the Polaris missiles and the Poseidon submarine based missiles) delivered truly outstanding results, which had indeed not been thought possible at the outset, the “freedom” to create beyond-the-envelope systems was removed when the urgency of the fear of falling behind in the cold war receded. The US department of defence stopped underwriting such “reckless” projects and installed the new Project Planning and Budgeting System (PPBS) that emphasized up-front planning (which was supposed to reduce uncertainty to the point where it could easily be managed) and efficient execution. Lenfle and Loch (2010) argue that the resulting stage gate process of product development has shaped managerial aesthetics until today, pushing managers to shy away from uncertainty rather than flexibly manage it. Indeed, in our executive education seminars on project management and innovation, we normally hear managers call for planning, predictability and target fulfillment, rather than asking how to inspire an organization to deliver the “impossible”.
Indeed, the culture of an organization sets the tone and shapes the aspirations of innovation activities. For example, role models influence individuals’ expectations for themselves (Van de Ven 1986). Another example lies in specific empirical evidence that a general “tolerance for failure” spirit in the environment stimulates individuals to take more risks, just via the setting of expectations, even when all specific incentives are unchanged by it (Hutchison-Krupat and Chao 2014).

3.4. Managing Stakeholders

Stakeholders refer to parties who may not have an official role but nevertheless have an interest in the direction of an innovation project, or can damage or stop it. Individual innovation projects often embody compromises among relevant trade-offs; it often happens that stakeholders (inside or outside the boundaries of the organization) may have different interests or perceive these compromises in different ways, because of direct interest conflicts, or because of different aesthetic judgments of what is “good”.

A “rational” stakeholder analysis would construct a stakeholder map, a list of stakeholders with their interests, and what the innovation does for them or does what they do not like. However, such a rational analysis falls far short of explaining stakeholder reactions, which are not rational in at least three ways (Figure 2).

![Levels of stakeholder reactions (from Loch and Kavadias 2010)](image)

In addition to their interests (their incentives in economics terms), stakeholders are also influenced by their relationships: an interest in relationships and reciprocity is built into human psychology (Gintis et al. 2003, Loch et al. 2006). No one decides in isolation; we all ask people whom we know and trust for advice, and information we receive is never evaluated “objectively but always “colored” by who the messenger is. Stakeholders (like any group) form an influence network (Rowley 1997) containing both influential “brokers” as well as people on the periphery. If you can get influential stakeholders on your side their network will “work for you”; this dynamic represents a non-linear feedback process that can result in an “epidemic of support” (or of resistance).

Below lies the cultural layer of “what is appropriate”. Culture refers to the socially (not necessarily consciously) learned routines and assumptions of social integration and problem solving that successive generations of a group’s members inherit (Schein 2004,
Changes may arise in unconscious cultural shifts, and rules may be enforced not only by official incentives and sanctions but also by social norms and peer pressure. Therefore, project specifications sometimes need adjustment to the range of socially acceptable configurations and outcomes.

Even deeper lies the layer of emotions. All humans like being acknowledged and respected, and they like positive relationships and reciprocate as well expecting others to reciprocate. Strong emotions are triggered (wanting to “punish”) when such expectations are violated (Urda and Loch 2013). Such behavioral influences are robust and often economically large (Loch and Wu 2008). In stakeholder management, this implies that individuals may find the project fundamentally beneficial yet still resist or impede its progress simply because the project manager did not ask for advice at a critical juncture, did not invite them to the milestone ceremony, or did not refer to them in an interview with the local press. The attitude of local inhabitants toward a project may be swayed by making the effort to engage local experts on the steering committee or on the project itself (thus giving respect and building a relationship). Once people see the project as “theirs”, they may naturally swing toward support, even if they do not like the project in terms of how they are affected. This emotional dynamic forms the basis of the power of “fair process”, or the effort by leaders to listen to and engage people when introducing changes (Kim and Mauborgne 1997 and 1998, Wu et al. 2008). The role of fair process in innovation initiatives has not been explored.

The two lower layers in Figure 2 may help the innovating team to understand the emotional aspects of attitudes toward an innovation and thus, to better mobilize support.

3.5. Managing Partners and Contracts

Contracts are core vehicles of governing partners and the sub-contractors of pieces of work in many innovation projects, an increasing trend in an era of “open innovation”. But contracts can handle only limited complexity (growing quickly for larger projects), and they are inflexible where flexibility is required to deal with the inevitable changes in innovation. If viewed as incentive structures alone, contracts cause the temptation to explore gaps in the understanding of the counterparty to create obligations that one can then exploit—a fallacious expectation because the other side usually finds a way to sooner or later stall in their turn or to retaliate (Von Branconi and Loch 2004). The well known temptation to “bid low and sue later” falls in this context, but it often leads to protracted business and legal battles, victimizing the project.

Economists have long recognized this limitation of contracts; already, Simon (1951) proposed that normal labor contracts represent “incomplete” (open ended) contracts, allowing a principal to choose from a pre-specified set of actions after uncertainty has been resolved (authority relationship). This contract can accommodate unforeseen events as long as the pre-specified action set remains valid. Later, economists translated the theory of repeated games into the idea of a “relational contract”, an “informal” agreement based on and enforced by the value of a future “relationship”, meaning future productive interactions (Baker et al. 2002).

However, the “rational” consideration of remaining constructive because of the value of future interactions is insufficient to explain how contracts are used in innovation. For example, Slaughter et al. (2012) examined the evolution of contracts between one large client and software development contractors. They found that the fundamental driver of the performance was the length of the relationship, which influenced trust and working style and also drove the type of contract chosen (typically, the client started with a fixed price contract, “controlling risk”, then moved to various types of incentive contracts, and when trust was finally established, to simple cost and time
reimbursement contracts). In the context of the previous discussion of bounded rationality combined with the emotional forces in relationships, these findings can be interpreted as showing how futile “incentive optimization” is, and that well-performing collaborations must be supported by relationships.

A specific example of this observation is the celebrated Heathrow Terminal 5 project, which applied an integrated approach that incorporated strategic systems governance with diligent process management that included supplier selection by track record (rather than the lowest bid price) and flexible contracts that rewarded problem solving (Davies, Gann and Douglas 2009). The project owner BAA “changed the rules of the game” by creating a new type of agreement based on two fundamental principles: the client bears the risk and works collaboratively with contractors in integrated project teams. BAA had to take responsibility for risks and uncertainties, whilst creating an environment within which suppliers could find solutions. Suppliers were repaid all the costs on a cost transparent “open book” basis and incentivized to improve their performance and innovate by bonuses for exceeding previously agreed “target costs” and completion dates. If the performance of a project exceeds target costs, the profits are shared among team members. This contractual approach was underpinned by routines to expose and manage risks rather than transfer or bury them, and offered incentives for innovation and problem solving (Davies, Dodgson and Gann 2009).

An even more extreme example of flexible contracts is the OSA Alliance between Orange (France Telecom’s mobile telephone arm) with its partners in managing roaming, the complicated agreements that allow regional telecom operators to provide service for a customer from other regions and get reimbursed by the telecom operator who has a contract with the customer and charges this customer for the roaming (Van Der Heyden et al. 2006). The “contract” that partner operators in the alliance signed up for did not specify any specific collaboration procedures or outcomes but was nothing but a specification of a collaborative problem solving procedure: how would the group make decisions in setting up a technical system, or a customer agreement, or a revenue sharing when it arose. Decisions were indeed made by voting, with safeguards that neither the large operators (with a revenue majority) nor the many small operators (with most votes) could force through agreements. Each specific agreement itself (what would normally be seen as a contract) became a mere technical description. This structure of agreements allowed the partners to keep collaborating flexibly and robustly in an environment of changing technologies and regulatory regimes (the regulatory bodies tightened rules on roaming which had become very profitable).

However, when we discuss such collaboration structures with project and program managers, they usually are very uncomfortable because it feels to them like a “loss of control.” And indeed, the fragility of using relationships reliably without succumbing to the temptation to use one’s own power (even if it is perceived to be stronger than it is in reality, as Von Branconi and Loch 2004 argue), is demonstrated by the continuation of the Heathrow Terminal 5 story: T5 owner BAA was acquired in 2006 and, “in a complete reversal of strategy (and to the surprise of many in the UK construction industry) decided to revert back to the traditional role of client as procurer rather than project manager, relying on ‘risk-shifting contracts’, detailed up-front specifications and inflexible routines” (Davies et al. 2016). Managerial risk aversion and obsession with maintaining control (or an illusion thereof) is alive and well, and its determinants may well be an interesting research topic in itself.

4. Research Opportunities

The summaries of important behavioral phenomena that we have discussed in Section 3 only scratch the surface and leave large gaps of knowledge. These gaps represent
important research opportunities. Table 2 outlines a few research questions, described at a high managerial level --- some of these questions may represent opportunities for multiple research projects forming research programs. The last comment in each box of Table 2 (in brackets) links the questions to behavioral issues that we have discussed earlier in this article.

**Table 2: Research Opportunities on Behavioral Phenomena in Innovation Processes**

<table>
<thead>
<tr>
<th>Innovation Process Step</th>
<th>Unsolved Managerial Challenges and Research Questions</th>
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| Creativity              | • We know creativity requires diversity and decentralization/localization of (early stage) experimentation and funding. Does creativity have the same effects on behavior and the same benefits at different organizational levels (e.g., at top management versus bench scientists)? (Status psychology of hierarchical levels)  
  • Where should creative experimentation happen, and where should budgets be located? (Balance of local identification and overarching vision)  
  • How should creative ideas (after the first experimentation step) be brought into the “formal” development process? How should help be given for creative people to interact with “processes”, and how should the “hurdle” criteria be increased without suppressing creativity? (Risk aversion and cultural aesthetics of sharing “half-baked” ideas) |
| Selection in the strategic context; cascading | A challenge in project selection is the conflation of bounded rationality and conflicting interests: top management and operations speak different languages (e.g., Finance and Market Share versus operational process indicators). Portfolio representations can elevate a complex analysis into a “strategic story” that fosters a shared understanding.  
  • What is an insightful portfolio “story” that helps a management team to make better decisions? (A balance between data-usage, “story telling” and understanding of and identification with a vision)  
  • Existing literature presents “standard” portfolios, but if the selection of innovation projects implements the business strategy, how can the portfolios be chosen in order to represent and evaluate the execution of THIS strategy? (Hypothesis: shoehorning a set of activities into a generic script narrows the breadth of actions considered and the appropriateness of actions chosen) |
| Technical and market risk, uncertainty | We have discussed risk aversion and its behavioral aspects. There is some evidence that risk aversion plays out differently at different organizational levels, not only because the stakes at senior management levels are higher, but also qualitatively: we have seen how “safeguarding” may be stronger at more senior levels, and moreover, risk aversion at senior levels seems to also take on forms of “control obsession”, which then also influences incentives given and creativity allowed. This suggests two important research questions (based on differences in incentives as well as social preferences of senior managers):  
  • (Normatively,) does the structure of risk aversion at senior management differ from operational levels, and if yes, how, and how should it differ?  
  • How can risk aversion at senior management levels be influenced? |
| Stakeholder networks and relationships | Literature has discussed stakeholder networks and influence in them, with tools such as stakeholder maps. Managers need a process of stakeholder management, a description of how stakeholder influencing (including its cultural and emotional aspects) is integrated into the project management of the innovation project. However, I am not aware of any well-derived descriptions of such a process. What are its contingencies, what are its characteristics in the context of the broader project management processes? |
| Contracts (working with contractors and partners) | We have discussed the usefulness of supporting contracts with relationships. But this seems to meet reluctance by managers (anecdotally) and be vulnerable to the temptation of recidivism to using contracts to assert control (although this control may be illusory).  
  • What are the reasons for an observed managerial preference for control? For example, is it myopia, or risk aversion, or ingroup-outgroup behavior?  
  • Can any arguments or cultural habits be designed to improve managerial flexibility enabling sustaining relational contracts? |

All of these opportunities spring from important managerial shortcomings in innovation management that are related to human behavior, psychology and culture, and all of them I have seen organizations struggle with, but have not been able to find sufficient
answers in existing research. I have no claim that this is a complete list of opportunities. The reader may view Table 2 as an invitation to use the lens of individual biases, small group (social preferences) and large group (culture) dynamics, across the stages of the innovation process, in order to generate additional observations of unexplained behavior and thus research opportunities.

Behavioral Operations offers a general framework for asking questions about observed practice in innovation, and thus for subsequent examination of the drivers and possibly improvements of this practice. As we have discussed at the beginning of this article, behavioral drivers are even more important in The Management of Technology than in routine processes. The Behavioral Operations framework is sufficiently flexible to integrate research approaches from adjacent fields (such as Economics, Organizational Behavior) and therefore carries a significant potential for building relevant and useful knowledge in Technology Management. The first 15 years of Behavioral Operations have only scratched the surface; I think there are large opportunities still ahead of us.

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