

Future Thinking in R&D Management

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It is often said that contemporary R&D brings about disruptive change. But will R&D itself escape disruption? Future R&D is shaped by radical transformations in the landscape of universities, changing patterns of doing business in industry, flexible policy-making and intensive community engagement. Major trends such as “Open Everything”, advanced machine intelligence, citizen science, massive collaboration, research data handling and ownership, the need for speed in the application of research results and knowledge ownership emerge that will impact drastically on R&D Management. This paper suggests the incorporation of Future Thinking in shaping R&D Management to prepare for these disruptions. It illustrates how Future Thinking reveals possible probabilities of the world of tomorrow affecting the ways in which we practice R&D Management. The foundation of Future Thinking lies in applying an Events-Technology-Behaviour approach to look at the future, where we can see change as a function of physical things plus perception plus what happens. Future thinking is then the integral of all change over time and strategy is the summation of all future thinking.

1. Introduction

Too often the role of R&D in shaping the future is the main theme in R&D management conversation, but not enough is being said about the impact that the future and its challenging demands will have on the way we strategise, deploy and practice R&D at national level, supported by national systems of innovation, in academia and in business. A major point of debate in R&D management and innovation management has been the interface between R&D organisations, such as government laboratories and universities, and R&D conducted in-house by the private sector. This interface has opened scholarly thinking and policy making on technology transfer, intellectual property protection and knowledge exchange. At present most of this thinking takes place in the known domain and language that is used, is fairly linear. However, the dynamics of markets are demanding something more – that of thinking in the complex, non-linear way, where speed of results and immediate impact become drivers for business success, and not only novelty resulting from reductionist based innovation. Market success is not only a function of being the best and being first anymore, but of addressing the need of the customer - a need not always understood by the customer itself. In this evolving world of future business, a new look at how we construct, conduct and deliver results from R&D is required. This paper suggests a new way of thinking that will guide researchers, policy makers and students of R&D management towards new horizons that will require culture change, courage and commitment.

1.1 Problem statement

Against this background of new challenges emerging from a rapidly changing world, drastic redirection and alignment may be required in how R&D management is practiced to ensure that R&D has its desired impact on nations, industries and the products and processes resulting from new knowledge. The problem faced by future R&D management is:

“R&D management approaches do not always include models to think about the future to address new disruptive forces that may lead to a radical change in R&D management strategy and practice”.

1.2 Research questions

To address the problem statement, the following research questions are postulated:

1. Are R&D managers aware of the future forces impacting on their specialisation domain?
2. Is their view of the future of R&D management liberal enough to prepare for radical change?
3. Is R&D management as a discipline, and are R&D managers, future ready?

1.3 Research objective

The objective of this research is to unveil some of the disruptive future forces that will cause drastic changes in R&D management and to establish their impact and interaction. This understanding will lead to a new realisation of changes required in the way R&D is managed today and to prepare the R&D management community to align their strategies with future trends and challenges and to act timeously to enable R&D to play a significant role in bringing about desired outcomes in this rapidly evolving future.

1.4 Outline of the paper

The paper will address the research methodology used, construct a landscape of future factors and forces that impact on R&D management obtained from the literature, discuss the results of a survey among R&D management practitioners on the impact of these forces and apply a Future Thinking approach to this understanding to extract caveats for R&D management and to recommend a way forward for R&D management to be future-ready.

2. Research methodology

The research included a literature search to discover the existing thinking on future forces that will impact on R&D management. The current perception on the impact of these forces among selected R&D management leaders at different levels was then tested in a survey. Following this impact perception study, the forces were categorised into the major dimensions of a “Future Thinking lens” that we developed to assist users to do mind-time travel and project themselves into the future to obtain a better understanding of what strategic decisions should be made in the present. Finally, a thought model of the future of R&D management is presented.

2.1 Literature search

The literature search was aimed at extracting the existing thinking in terms of future impacts on R&D management. It was used as a background against which speculation of the important influencing forces could be made and served as a characterisation of the future landscapes that would be important for R&D management.

2.2 Impact survey

The impact survey was conducted among R&D management leaders and practitioners, using a web-based survey tool. The survey was circulated to university executives (Deputy Vice Chancellors, Deans or Directors of Research), research council executives responsible for R&D and innovation, individuals with many years of experience in R&D management and researchers. Most of these respondents were based in South Africa, but some were also from international R&D management institutions. The survey tested the following aspects of future forces on R&D management:

- Emerging technologies
- Behaviour of clients of R&D
- Behaviour of R&D practitioners
- R&D management responses
- Major events (geopolitical, economic, natural, social, demographic, etc.)
- Comments and reflection

2.3 The Future Thinking lens

The approach towards Future Thinking is to create a space defined by a triangle with corners signifying technology, behaviour and events. This space is now transformed into a lens onto the future by "spinning" the triangle. Figure 1 shows how this is achieved by "spinning" the triangle, revealing inter-parameter impact phenomena and creating the lens by forming a continuum. As the parameters of technology, behaviour and events are moved through space and time, they influence each other through inter-parameter impact phenomena that are dependent on the direction of spin. For example, a clockwise spin leads to technology influencing events, events influencing behaviour and behaviour influencing technology. An anti-clockwise spin results in technology influencing behaviour, behaviour influencing events and events influencing technology. Impacts that emerge in a clockwise spin of the lens are, for example, the development of new governance systems (between technology and events), introducing change paradigms (between events and behaviour) and initiating new technology innovation (between behaviour and technology). In an anti-clockwise spin lens, impacts that emerge include, for example, creating user behaviour (between technology and behaviour), social innovation (between behaviour and events) and applying mitigation measures (between events and technology). This Future Thinking lens is used in this paper to reveal some critical future changes required to R&D management.

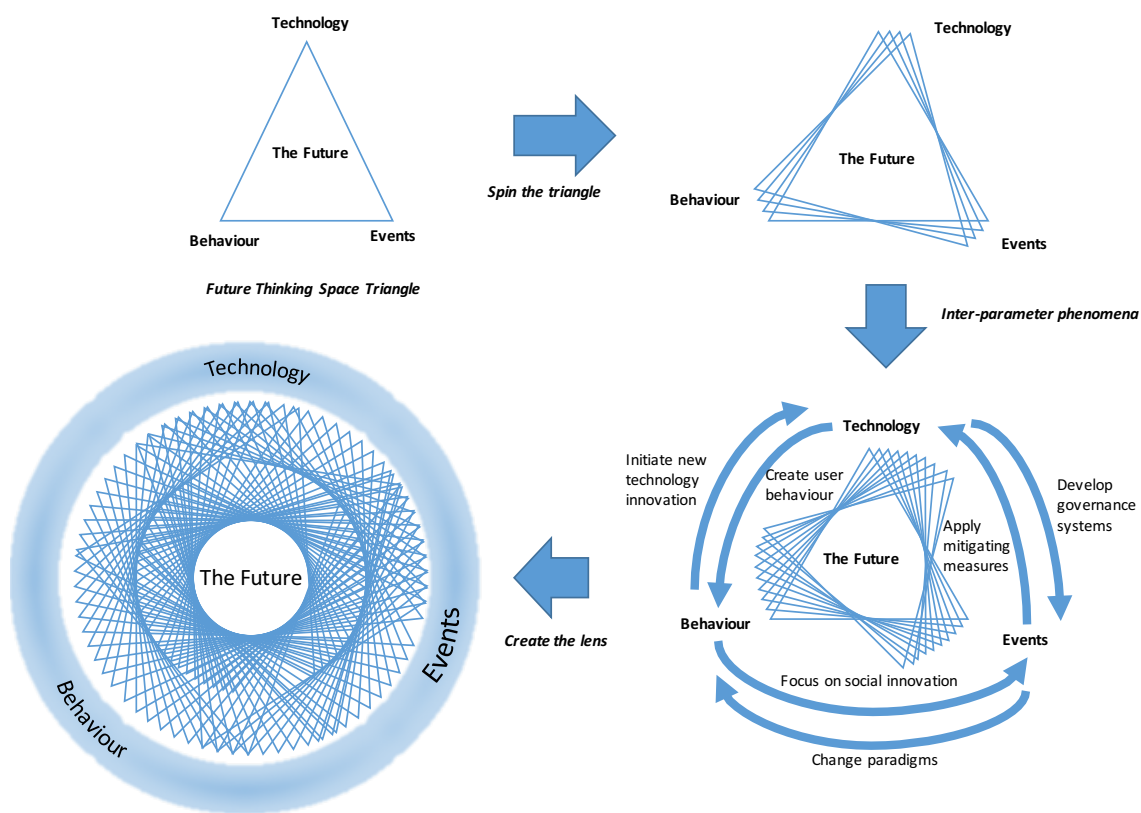


Figure 1. Creating the Future Thinking lens

3. Results

3.1 Existing thinking

Several papers available in the literature address the future of R&D, although it is not a topic enjoying a large number of publications. In their paper (Farrington, Crews & Blenkle 2013, 58) pose the question: "What will R&D look like 25 years onward, in 2038?" They state that it will be determined by trends in technology, business and culture, that include: R&D will increasingly be done by freelance specialists not having a career with one organisation only; traditional patents may become irrelevant as a result of the increasing pace of innovation and open sourcing; larger influence will be seen on R&D by grand challenges to attain sustainable solutions; virtual R&D collaboration may become the norm; simulation may increasingly replace physical testing; physical augmentation of the human body, neuro-enhancement through pharmaceuticals and the use of augmented reality devices to project digital information on physical reality may become standard aids; machines (artificial intelligence) may increasingly be doing research and the

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rising era of women in research will prevail. They state that these trends will necessitate new paradigms to be developed in R&D management.

(Nobelius 2004, 369) describes the history of R&D management over six generations. This, very classical approach, includes in essence: R&D as an ivory tower (1950 – mid-1960s); R&D as business (mid-1960s – early 1970s); R&D as a portfolio linked to strategy (mid-1970s – mid-1980s); R&D as an integrative activity where customer requirements are important (mid-1980s – mid-1990s); R&D as a network, focusing on extended collaboration (mid 1990s onwards); and then proposes that the sixth generation of R&D management will refocus on the research part of R&D, while pursuing more radical innovations. In the years that followed, large debate prevailed about the emphasis on R or D with a subsequent school of thought that the one is driven by more basic science and the other more by engineering development and innovation. These phases were accompanied by different R&D management styles. Initial views of R&D spend as a measure of competitiveness have been replaced by the ability to the rapid translation of R&D into products and services that satisfy market needs. This followed since R&D, although leading to new technology, was not commercialised effectively. The first five generations of R&D management outlined by the Nobelius paper were accompanied by managerial approaches and company responses that include: (1) stimulating scientific advances and choosing location after competencies (corporate research labs); (2) appointing internal customers and gathering ideas from the market (business unit development); (3) structuring R&D processes, evaluating long-term technology strategies and integrating R&D and marketing (R&D projects); (4) running parallel R&D activities, involving suppliers and lead customers in R&D and integrating R&D and manufacturing (cross-functional projects); and (5) involving company networks, integrating systems and separating or linking R with D (cross-boundary alliances). During the evolution of these generations of R&D, the complexity of R&D has expanded dramatically. Complexity has been enhanced through: multidimensional needs; more actors in the R&D and market place; product and technology complexity; and high rate of return demands. This increasing complexity is leading to the sixth generation of R&D management which involves more radical innovations supported by a broader technology base and more distributed technology sourcing. This implies a broad spectrum of R&D providers. The shift towards the sixth generation requires the likelihood of identifying, integrating, and developing breakthroughs affecting whole industry segments. This results into a requirement that when foresighting the future, caution is exercised to not overestimate the business impact of technological changes in the short run, while underestimating in the longer run. It is stated that in this emerging R&D system, new opportunities will arise for intermediaries for the research efforts towards the potential users or developers.

The recent merging of understanding in R&D management and knowledge management has also opened up new avenues for viewing R&D behaviour. R&D and non-R&D workers all gain experience and knowledge in the course of their normal work, as outlined by (Lee and Walsh 2016, 345). The origin of innovation from areas outside R&D has opened the question on the value proposition of R&D in the future.

Research managers, especially in long term innovation programmes in corporations, are typically challenged by learning about markets that do not exist yet; finding breakthrough ideas; transitioning innovation to operations; reciprocal influence between innovation and strategy; and continuation in R&D and innovation efforts (Farrington, Henson and Crews 2012, 26). Foresight methods can facilitate a proper approach to these challenges, especially if the foresight approach move from one method to the next in a logical progression, rather than using these methods individually. The paper suggests that useful foresight methods over the project phases of discovery, extrapolation, integration and planning could include internal futures audit and weak signals environment scan (discovery); implication wheels and technology forecast (extrapolation); inductive scenarios and participatory futures (integration) and point of view opinions on evolutions and trends (planning) (Farrington et. al. 2012, 28). These approaches have been used successfully in understanding the evolution of future R&D foci and priorities.

This literature scan has specifically revealed a basis for the argument that Future Thinking is required to prepare R&D management and R&D managers to make the right choices today to help in shaping tomorrow's R&D. It has:

- Indicated future factors and forces to consider in R&D management
- Highlighted the evolution in R&D management approaches over time and pointed out that a new regime where complexity is the basis for operation is considered
- R&D business models may emerge where innovation outside the R&D environment contribute largely to value
- Foresight processes and methodologies can be applied to strategically position future R&D management, especially for longer term R&D and innovation projects

3.2 Future Thinking

The three pillars of Future Thinking for R&D management are now constructed based on information that emerges from the literature discussed above, complemented by knowledge originating from experience built up by the author as

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consultant to governments, universities and industry on future strategies reliant on R&D, future thinking and policy development.

3.2.1 Technology

The following emerging technologies have the capacity to disrupt the way R&D management is practiced today. Some of them may be remote in terms of their application maturity, but all of them are possible, based on demonstrators that have been developed already:

- Massive virtual collaboration (social media)
- Advanced machine intelligence (robotics, automation and computer controlled R&D)
- Augmented reality (projecting digital information on physical objects)
- Simulated environments (virtual reality and interactive immersive gaming)
- Globally connected research infrastructure
- Big data

3.2.2 Behaviour

Behaviour is categorised into three sections: behaviour of R&D clients that will influence R&D management; behaviour of practitioners of R&D; and behaviour in R&D management that lead to R&D management responses that will be critical for future success.

Behaviour of R&D clients

- The need for fast solutions resulting from R&D outcomes
- The need to address complexity
- The need to find co-funders of R&D (crowd funding models)
- Embracing open source solutions (including open innovation)
- Following first-to-market strategies, rather than long term IP leadership
- Utilising virtually connected R&D teams
- Rising importance of social innovation
- Decreasing importance of classical R&D providers
- Embracing entrepreneurship in R&D

Behaviour of R&D practitioners

- Embrace open science (or “Open Everything”, including open data, open access, open source, open notebook, open peer review, etc.)
- Increasingly involve citizen science (including crowd sourcing)
- Make R&D more entrepreneurial (look for and seize opportunity and doing business out of R&D)
- Become connected researchers (social networking)
- Think from the complexity space more than from the discoverable (complicated) space (Refer to the Cynefin Framework, (Snowden and Boone 2007, 72))
- Focus on fast impact of research
- Adopt a culture of sharing everything
- Work alongside machines that do automated R&D
- Embrace co-creation and co-responsibility for research solutions

Behaviour in R&D management (responses that will be critical for R&D management success)

- Let go of the notion that universities, government laboratories and industry laboratories are the sole custodians of R&D
- Embrace open science (and “Open Everything”)
- Recognise the importance of crowd funding for R&D
- Accept machine automation in R&D
- Realise that data ownership and intellectual property rights will be redefined as a result of increasing innovation pace and open sourcing
- Adopt a holistic approach to R&D
- Accept the need for speed to arrive at solutions through R&D and to apply them where they make an immediate impact
- Promote complexity thinking and non-linear approaches to R&D
- Accept that R&D will increasingly be done by freelance specialists not having a career with one organisation

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only

- Realise that R&D and non-R&D workers all gain experience and knowledge in the course of their normal work and contribute to solutions classically found through R&D only
- Adopt the view that competition in R&D will be replaced by collaboration in R&D
- Promote that building the mind of the future will replace archaic education styles
- See the importance of creating partnerships between governments, industry, research institutions and citizens
- Move towards utilising globally shared research platforms and research infrastructure
- Promote global open standards
- Identify and reduce barriers to inter-institutional, inter-disciplinary and international collaboration among governments, research institutions, industry and citizen groups

3.2.3 Events

Events are categorised as geopolitical, economic, natural, social and demographic. Major events that will impact on R&D management are listed below from information in the literature, previous knowledge and feedback from the survey respondents in this research.

Geopolitical

- Safety, security and military conflicts, global terrorism
- Ideological and religious tensions
- Climate change agendas and agreements
- Political alliances
- Competitiveness among nations (national pride)
- Disbanding of large global groupings, e.g. BRICS, EU
- Space exploration
- Multinational and continental R&D programmes (e.g. Horizon 2020)

Economic

- Economic growth in emerging economies
- Growing energy needs
- Global recession
- Decrease in government R&D funding in real terms
- Expansion of multinationals
- Trade barriers
- Dumping
- Shift in economic strategies from cost focus to value focus
- Connectedness and interdependence of economies
- Phasing out of major currencies (e.g. Euro)

Natural

- Depletion of natural resources (e.g. rare earth metals, helium, etc.)
- Climate change and global warming
- Water scarcity
- Sustainability of agriculture and food security (including impacts on nutrition and health)
- Disasters (e.g. drought, earthquakes, wild fires, floods, etc.)
- Environmental degradation (e.g. over-population, massive urbanisation, resource exploitation, etc.)

Social

- National well-being
- Inclusive innovation for development
- Massification of education
- Unemployment
- Poverty
- Communicable and non-communicable diseases
- Inequality and human rights
- Social media and the connected humanity
- Digital inclusion
- Increased virtual vs. decreasing personal interaction
- Citizen participation

- Social innovation
- Gender issues

Demographic

- Change in demography of researchers
- Bottom-of-the-pyramid needs
- Migration
- Cultural mix
- Aging populations vs. youth
- Human settlements and migration
- Urbanisation
- Increased division between developing and developed world; rich and poor
- The rise of the Millennials in R&D

3.3 Impact of future trends on R&D management

This section provides an analysis of the survey conducted among R&D management executives and specialists. The opinions received are ranked in terms of the weighted average impact intensity as expressed by the respondents.

3.3.1 Emerging technology

Figure 2 represents a view of the impacts that emerging (disruptive) technologies will have on R&D management.

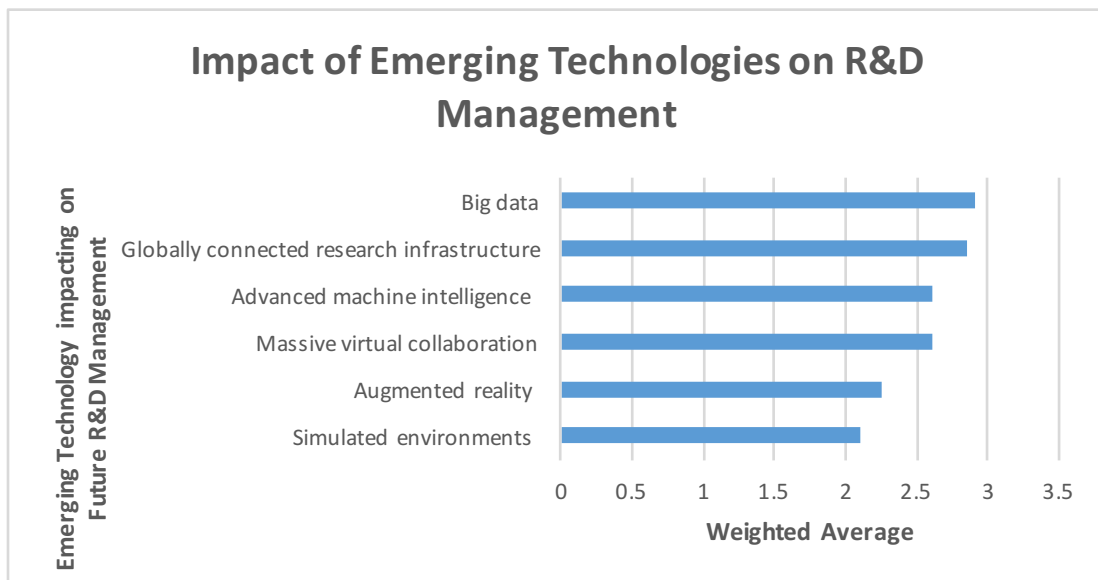


Figure 2. Survey results illustrating the level of impact that emerging technologies will have on R&D management

It is clear that the opinion of R&D managers is that big data and globally connected research infrastructure will have the largest future impact on the way R&D will be managed, followed by advanced machine intelligence and massive virtual collaboration through social media. The opinion was that augmented reality and simulated environments will influence R&D management to a lesser extent. These are technologies available to both researchers and R&D managers, but they are also disruptive technologies in all aspects of the knowledge economy, meaning that the clients for research will also be faced by the realities these technologies will bring.

3.3.2 Behaviour

Three views of behaviour, for R&D clients, R&D practitioners and R&D managers, that will influence the future of R&D management are presented.

Clients of R&D

In assessing the importance of the impact of the behaviour of clients for R&D (those that commission R&D),

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the survey (see Figure 3) indicates that the opinion from R&D management leaders and practitioners is that R&D clients in future: will mostly want fast application of R&D outcomes; will increasingly see the rising importance of R&D applied for social innovation; will insist on the involvement of virtually connected R&D teams; will be looking for co-funders for R&D; and will see the need to conduct R&D in the complexity domain. To a lesser extent first to market strategies rather than IP leadership will drive R&D client behaviour; R&D clients will look for entrepreneurship in R&D; open source solutions will be embraced; and classical R&D providers (universities, science councils and industry labs) will decreasingly contribute to R&D needs of the future.

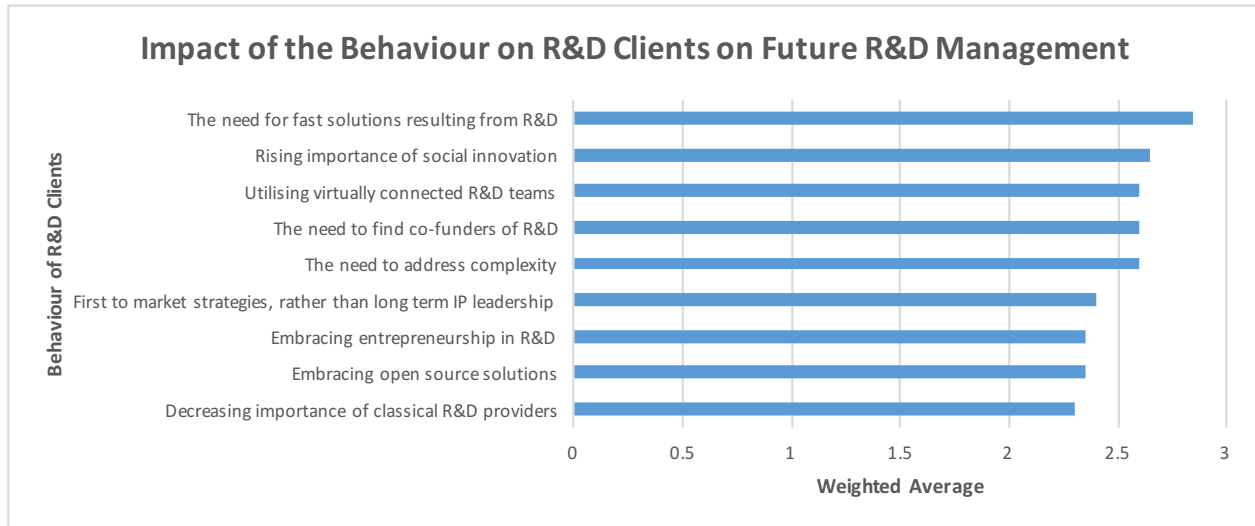


Figure 3. Survey results illustrating the level of impact that R&D client behaviour will have on future R&D management

R&D practitioners

The behaviour of R&D practitioners (principal investigators and their teams) that will highly impact on the future of R&D management (see Figure 4) includes: researchers increasingly becoming connected through social media; embracing open science and making R&D more entrepreneurial. Focus on fast impact of R&D, embracing co-creation and co-responsibility for research solutions and ability to think from a complex space (where there is no cause and effect, but emergence), rather than from a discoverable space (the classical R&D domain of cause and effect) will further shape R&D management. The surveyed opinions indicate that behaviours that will contribute to a lesser extent to R&D management are the involvement of citizen science; adopting a culture of sharing everything and working alongside machines that will automate R&D.

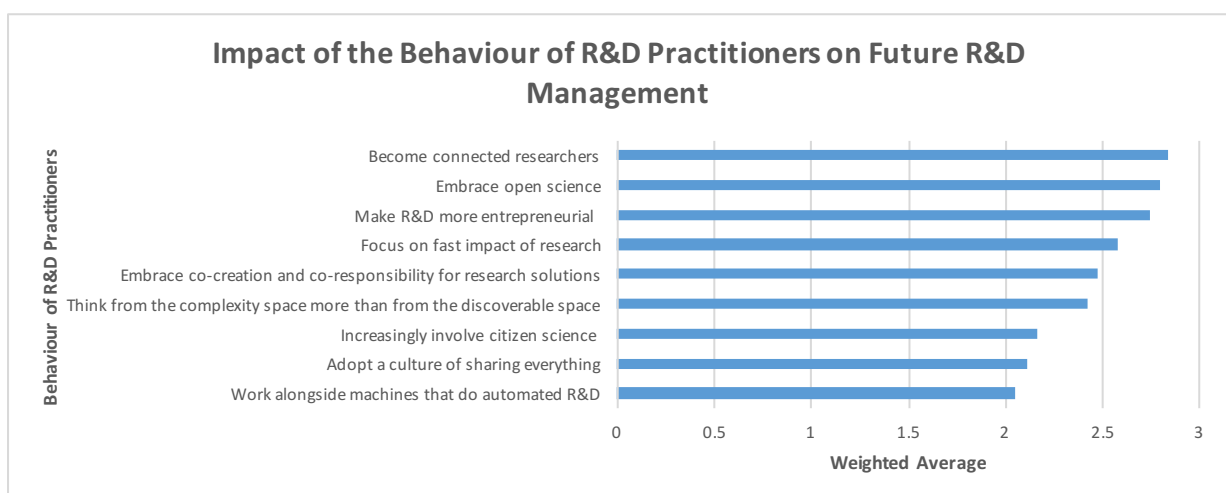


Figure 4. Survey results illustrating the level of impact that R&D practitioner behaviour will have on future R&D management

R&D management

The impact of typical R&D management responses on future R&D management was probed next. The impact levels are shown in Figure 5.

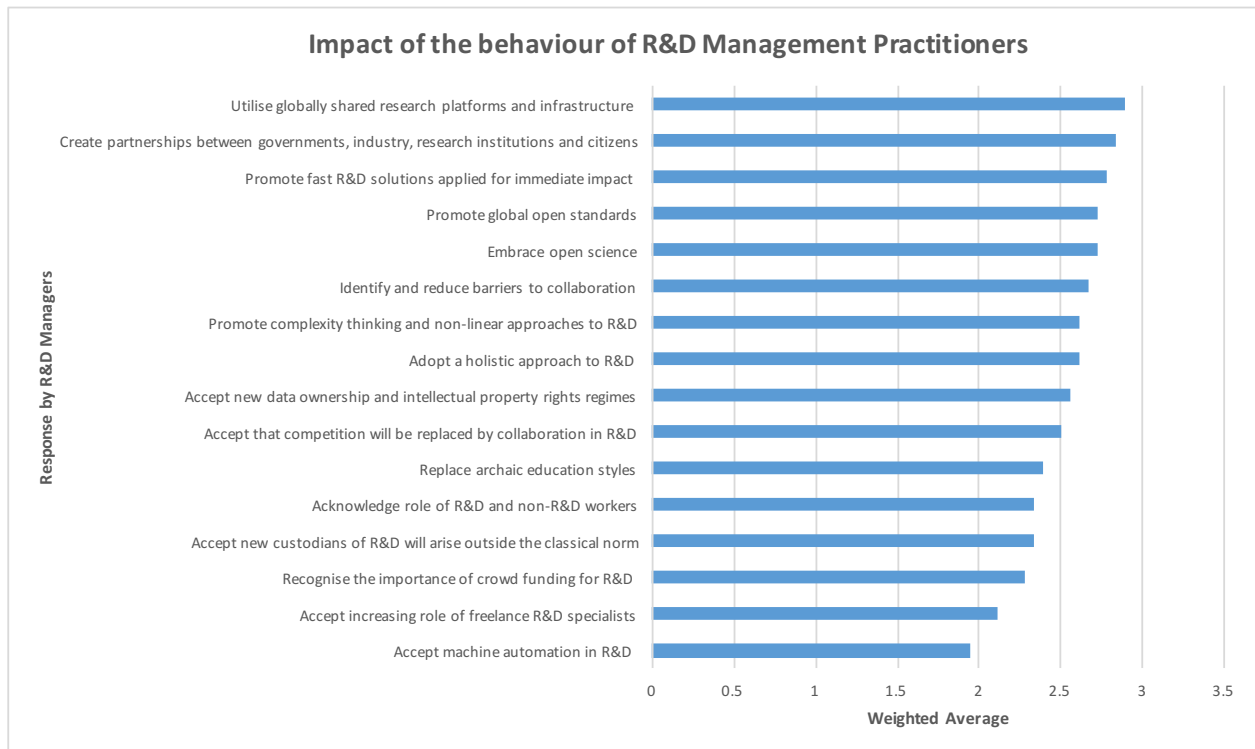


Figure 5. Survey results illustrating the level of impact that R&D management practitioner responses will have on future R&D management

On the top end in terms of impact, responses were clustered to a large extent around the known domain: global sharing of research platforms and research infrastructure; the importance of partnerships; the need for fast application of R&D outcomes; the promotion of global open standards and embracing open science. This is followed by identifying and removing barriers to collaboration; the promotion of complexity thinking and non-linear approaches to R&D; and an acceptance that new data ownership and intellectual property rights regimes may emerge as new open standards and knowledge sharing are introduced. Collaborative, rather than competitive approaches will have to be followed in R&D; and archaic education styles will have to be replaced by newer, innovative ways of shaping future minds. Not so important in terms of impact are: the realisation that the contribution non-R&D workers may be significant on R&D in knowledge organisations and the knowledge economy and the fact that new custodians of R&D will arise outside the classical academic, government and industry R&D spheres. Of lesser impact are seen: crowd funding as a means to support R&D; the role that freelance R&D specialists will play and the fact that machines may be assisting humans in doing R&D.

3.4 Applying the Future Thinking lens

The Future Thinking lens was introduced in section 2.3. It was stated that as the parameters of technology, behaviour and events are moved through space and time, they influence each other through inter-parameter phenomena that are dependent on the direction of spin. From the results discussed above and given the number of technologies, the behavioural impacts and the variety of events that can play out individually or concurrently, it is indeed a complex environment to visualise. These influences and the view they are presenting on the future of R&D management are now discussed in terms of cross-cutting impacts that will determine that future and that can be managed. The examples given below are by no means exhaustive and serve to illustrate how the “Future Thinking lens” can be applied as a thought tool, but also used to extract a significant understanding of the future of R&D management through cross impact analysis and narrative.

3.4.1 Anti-clockwise spin of the Future Thinking lens

Technology influencing behaviour – Create user behaviour

Research data is on the leading front in shaping the understanding and processes of working with big data. These

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massive data environments are created in particular through the global connectivity of research platforms and research infrastructure (take CERN and the SKA – Square Kilometre Array - for example). Collection of this data and processing of it is enhanced through advanced machine intelligence. Through the growth of social media, that is also founded on big data, massive virtual collaboration will just mean the consequential growth of big data. In utilising these data resources, augmented reality will superimpose information on physical objects in such a way that the whole world and its natural and built environment will become one huge laboratory. Big data will also contribute to model and simulate environments before they are experienced or changed. A whole new immersive learning environment is opening up for educating and training the minds of the future.

How will these technologies that work in unison influence behaviour? Future R&D management will be influenced by three behavioural groups as outlined above. These are the clients for R&D, the R&D practitioners and the R&D managers themselves. These technologies and their interplay will certainly have a positive impact on how the behaviour of clients for R&D will be shaped in a market-push fashion. They will get faster solutions to problems and opportunities that exist. The integrated modelling capacity will have a positive impact on new ways of bringing about social innovation. Access to virtually connected R&D teams will create the opportunity for the involvement of larger teams to service R&D requirements. This connected and globally distributed R&D community will bring about more partners for investing in R&D. The technologies will enable researchers to operate in highly complex environments and solve complex problems. The need for speed and openness will push first-to-market opportunities and the slow and ineffectual intellectual property rights environment will be reshaped with lead and compete, rather than protect and enforce. A high exposure to connected knowledge will open up opportunity for R&D to become entrepreneurial, not only in the classical R&D institutions, but also as a new business form. Because of the interconnectedness and access to knowledge, researchers will co-create and find co-responsibility for their R&D with clients and other researchers. They will start drawing in ordinary citizens as sensors and as problem solvers, leading to more acceptable social innovation and human-centred R&D solutions. A new generation of researchers that grew up in a sharing culture will enter R&D, being prepared to give and take in massive collaborative effort. R&D managers will be part of this revolution of technology influencing behaviour and will promote and support the notions that are emerging, break down barriers to massive collaboration, adopt a holistic approach to R&D management and be instrumental in creating opportunity in the market for R&D. They will adopt new management approaches that are inclusive of R&D and non-R&D knowledge, accept the emerging business aspects of R&D and be unafraid to change their traditional styles of R&D management.

Behaviour influencing events – Focus on social innovation

How will the behaviour of clients for R&D, R&D practitioners and R&D managers influence the events that have been identified that will have the largest impact on R&D management? These events have been identified to be of a geopolitical, economic, natural, social and demographic nature. By adopting the behaviours outlined above, social innovation will not be a reactive approach anymore, but prepare humanity through R&D to face these events. A multitude of permutations exist from the identified events, and their timing and roll-out can either be evolutionary or abrupt. If the behaviour around R&D is demanding massive connected research that is of a collaborative and open nature, geopolitical conflict may be restricted, based on shared knowledge and values that may evolve from such social connectedness. Access to data, speed of processing data and complexity thinking may result in safety and security solutions that address global crime, cyber-crime and injustice. Collaborative behaviour in research will inevitably lead to addressing common challenges. The world is a large economic hub, interdependent and interrelated, depending on international trade to ensure wealth creation, human well-being and stable societies. Crime is interlinked with weak economic growth and the digital divide is still one of the large separators of people. The identified behaviours surrounding R&D have the potential to act as a binding force to equal out economic imbalances and to create a global trading house. On the other hand, such interdependence and connectedness has the potential to lead to massive joint economic collapse. Much of the geopolitical stress and economic fragility in the world is as a result of natural events. These disasters or shortages in resources lead to economic demise, health deterioration, personal stress and conflict. One of the largest drivers for collaborative research is addressing common challenges, especially natural ones that know no political borders. New behaviours identified as crucial to R&D execution will have a huge impact on education. Not only will the radical new data environments and connectivity present opportunity for basic and further education, but the increased involvement of citizens in science and R&D will have an educational value that will enhance social innovation and solve global problems. Probably the largest impact on world events will be through the entrance of new generations of researchers. They will adapt naturally to the enhanced connectivity and sharing and collaboration. They have also grown up in an era of making complex decisions on the fly, the on-line gamers of yesterday. They will easily take to simulation and modelling and immersive decision making. The potential for innovation at the edges of cultures that mix is massive. Another event that is on the go is that of urbanisation. The behaviours surrounding R&D will have to address social, health, technological and environmental issues related to high density populations, the production of food, waste handling, energy generation and transport in megacities.

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Events influencing technology – Apply mitigating measures

The identified events will also create opportunities to develop new technologies through R&D to mitigate the impacts of these events. These very same technologies can also be applied in R&D and R&D management. The technologies to be either developed or deployed when a certain event or a combination of events take place all require R&D and the R&D requires management. Defence technology development peaking around wars and threats; space technologies that are developed around major space programmes; security technology developed to counter crime; surveillance technologies developed to monitor natural disasters, are all aimed at mitigation of the influence of these events. These events will bring about many emerging and disruptive technologies. This will continue, with well managed R&D right in the centre of these mitigation initiatives, and also standing to gain from it is R&D management.

3.4.2 Clockwise spin of the Future Thinking lens

Technology influencing events – Develop governance systems

Where technologies are the cause of negative aspects leading to events, they need to be managed in a proper way. Such governance systems may include privacy protection in massive collaborative environments or augmented reality; ownership and jurisdiction over data; access control to global research infrastructures; ethics in simulated environments; exposure of humans to machine interfaces; “machine rights” as machine intelligence increases rapidly; human-centeredness of social innovation technologies; unfair advantage through access to technology; environmental and health impacts of technology; and others.

Events influencing behaviour – Change paradigms

The events that were identified as having a major impact on R&D management may exist individually; co-exist, amplify each other; merge; diverge; or annihilate each other. They may appear or disappear abruptly. Many exist already, or may show clear patterns of emergence. How do they change R&D management paradigms when they affect behaviour? Drastic polarisation and offensive behaviour on geopolitical front will influence massive collaboration paradigms; economic stress will lead to under-investment in R&D; fast spreading epidemics (e.g. Ebola) will create voluntary data sharing; environmental degradation and climate change will necessitate multinational longitudinal R&D which will require dedicated agreements; continued and rising unemployment may result in a distrust in citizen participation in science and in social innovation; global recession may cause collaboration to be returned to competitiveness; collapse of economic alliances may shut down major continental and collaborative R&D initiatives and funding programmes; the quest for agile R&D implementation driven by strong economic growth and opportunity will result in entrepreneurship in R&D (both in existing R&D providers and in new business forms), etc.

Behaviour influencing technology – Initiate new technology innovation

The behaviour of the clients for R&D will influence how suppliers and managers of R&D behave and what technologies they adopt or develop. The technologies identified in this paper are existing, albeit emerging, and some may become disruptive. Agility in R&D management is required to either identify and adopt or develop technologies that do not exist yet to strengthen their service to the R&D market. New algorithms will be required to maximise the impact of big data; artificial intelligence will be required to create, develop, monitor and manage complex environments; and decision support systems need to be improved to assist in agile decision making in research priorities, funding and assessment. Virtual reality, already appearing in social media, should be investigated as a collaborative space for R&D without the need for travel; data storage should be adequately energised and data security should be radically improved, etc.

4. Discussion

This paper presented an approach to Future Thinking in R&D management. It focused on future impacts on R&D and R&D management and not the future effects of R&D itself. As such it attempted to be a thought piece on the future of R&D in practice, and in turn R&D management as an academic discipline.

It started off by looking at the current thinking as communicated by the future studies literature and emerging from consulting work on what the major future impacts are going to be on R&D management. From this information it extracted major influences in technology and behaviour of people to be tested for perceived impact among a group of R&D executives, managers and practitioners. The survey results were used to prioritise these factors and forces and to measure the current understanding of practitioners in the discipline of R&D management on future impact. The same group was also asked to suggest the major events that will influence R&D management in future. To assist in Future Thinking on R&D management, a methodology was used that was developed by the author, utilising a “Future Thinking lens”. This is a thought tool enabling cross impact analysis among technology, behavioural and event influences. An understanding of some major features of the future of R&D management was obtained.

Three research questions were posed in section 1.2. These were:

1. Are R&D managers aware of the future forces impacting on their specialisation domain?
2. Is their view of the future of R&D management liberal enough to prepare for radical change?
3. Is R&D management as a discipline, and are R&D managers, future ready?

4.1 Awareness of future forces

The discussion on the future of R&D management has been ongoing in the literature, albeit not an area where a lot of papers are available. R&D managers, in context of their responsibilities, have taken note of many of these future forces and influences. It is also evident from the feedback in the research conducted for this paper that they consider these forces and influences seriously. In terms of the general prioritisation, the technologies and behaviours that are known at present receive the most attention as having a critical impact. Some technologies or behaviours that are still over the horizon are not seen as critical. It is in this perception that the danger lies for R&D management as a discipline and business. Amplified by the influence of the identified events, these over-the-horizon future forces and influences may rapidly arrive in the midst of present strategic planning and decision making that may not be adequate to deal with them.

4.2 Liberal future thinking in R&D management

The responses received indicate that the more radical influences identified, such as the disappearance of current intellectual property protection regimes; letting go of competitive strategies in R&D in favour of collaboration; getting rid of archaic education styles; acknowledging the contribution to R&D from non-R&D workers; losing of custodianship of R&D by universities and government and industry laboratories; citizen science and crowd funding; freelance R&D specialists; and the fact that intelligent machines may do R&D are far beyond the strategic and operational horizons of R&D managers. This may be because their tasks descriptions are more focused on the present and medium term, but it may also be in response to protectionism of what is in place and working.

4.3 Future readiness

Building on Technology Readiness Levels (Straub, 2015), Manufacturing Readiness Levels (DoD, 2011), and the Capability Maturity Model Integration (CMMI), a Future Readiness Levels and a Future Readiness Index is under development by the author. The Future Readiness Levels (FRL) are based on readiness at the technology, behaviour, event and future levels in line with the Future Thinking space. Several readiness parameters are defined for measurement. An assessment is then done through facilitation and surveying on each of the parameters identified for the FRL at the three corners of the Future Thinking lens. Their importance is determined and their state of application is quantified. A FRL factor is subsequently calculated. A Future Readiness Index (FRI) is then provided based on the entire Future Thinking space. This work is in progress and the FRL tool has not been applied in the research in this paper.

Qualitatively, based on the comments made in the previous two paragraphs, there is a strong indication that R&D management and its practitioners are future aware, but not future ready.

5. Conclusions and recommendations

A problem statement was suggested in section 1.1. This read:

“R&D management approaches do not always include models to think about the future to address new disruptive forces that may lead to a radical change in R&D management strategy and practice”.

The research and analysis presented in this paper provide enough evidence to substantiate that this problem is real. Although an awareness exists among R&D management practitioners that new approaches have to be adopted, there seems to be a reluctance to identify radical influences and forces as critical at present. This paper provides a thought tool to assist in Future Thinking that illustrates how the parameters of technology, behaviour and events when influencing each other, can drastically result in an understanding of what future strategic actions should be in place to ensure the effective impact of the R&D management discipline.

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In order to scope a future R&D management regime, the following will be important: give new properties to government policies to embrace open science; identify and reduce barriers to inter-institutional, inter-disciplinary and international collaboration among governments, research institutions, industry and citizen groups; create an enabling environment by moving to globally shared research platforms and research infrastructure; agree on and promote global open standards; revise views on intellectual property originating from research; embrace Big Data and the era of the algorithm, artificial intelligence, virtual simulation and instantaneous virtual presence; create partnerships between governments, industry, research institutions and citizens; use citizens to identify challenges, as sensors and as solution providers (crowdsourcing and citizen science); embrace the millennial characteristic of sharing everything; follow the social networking tsunami; use machines to augment massification of science; develop innovative funding approaches for science such as crowd-funding and entrepreneurial research; introduce citizen science in school and university curricula and utilise a national/regional/global brain trust.

To successfully adopt a new regime for R&D management that will face the global challenges, it will be necessary to: face paradigm changes; embrace co-creation of and co-responsibility for research solutions; create a culture of volunteerism; focus on human embracement of R&D outcomes and introduce benefit measurement in social innovation. This will require that some current paradigms in R&D have to be shattered: governments, universities, research institutions and industry cannot be the sole custodians of research and science anymore; current intellectual property thinking in research outcome protection will not prevail; competition in science will be replaced by collaboration in science; the guru will be replaced by the wisdom of the crowds; sharing is the new protection; building the mind of the future will replace archaic education styles and people and machines (crowd intelligence and artificial intelligence) will increasingly work alongside each other to solve global challenges.

A challenging, but exciting future awaits R&D management.

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