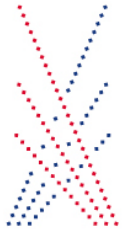

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Dialogical Mechanisms of Organizational Knowledge Creation in the Context of the Technological Innovations' Front-End

ABSTRACT

Dialogical mechanisms of organizational knowledge creation (OKC) are important in developing technological innovations across the fuzzy front-end. Yet, we understand less about how these mechanisms operate, how they are patterned and how to steer them towards concrete outcomes. This empirical paper develops a unique framework of the dialogical mechanisms of OKC in the context of the technological innovations' front-end. Using 11 qualitatively studied technological innovations the paper explores the patterns of dialogical mechanisms along five overlapping front-end OKC stages – knowledge-inception, -assessment, -expansion, -refinement and -crystallization. The framework distinctively unearths two types of dialogical mechanisms not distinguished before, and sheds new light on their contrasting roles, functions and effects not illuminated before.

Keywords: dialogical mechanisms, organizational knowledge creation, technological innovations, front-end, exploration versus exploitation

Dialogical Mechanisms of Organizational Knowledge Creation in the Context of the Technological Innovations' Front-End

Introduction

Organizational knowledge creation (OKC) is a process of scholarly and managerial interest (Schultze and Stabell, 2004; Un and Cuervo-Cazurra, 2004). It involves, among others, two important aspects: a) the interactions, e.g. between agents, which b) progressively build, or construct, new knowledge; the two aspects being inexorably connected (Nonaka, 1994). Yet, over the years in the OKC literature, the interactions have taken a life of their own and are largely theorized as disconnected from the task of progressively building new knowledge (e.g. Cook and Brown, 1999; Orlikowski, 2002; Ribeiro and Collins, 2007; Spender, 1996). Approaching interactions as mechanisms, i.e. a set of parts that performs a task, (re)connects them to the knowledge building task. This approach could unearth insights and patterns not captured before. A useful task context is developing technological innovations, especially across their fuzzy front-end (Brentani and Reid, 2012), because they are risky and complex to develop, and, yet, represent valued outcomes of OKC (Lavie and Drori, 2012).

Dialogical mechanisms are important meaning-making interactions. They consist of a dynamic interplay between opposing voices, affecting each other (Hargrave and Van de Ven, 2006). They overcome, but not synthesize, the thesis-antithesis conflict, e.g. exploration-vs-exploitation (Costanzo and Di Domenico, 2015). Notwithstanding their importance in OKC (Tsoukas, 2011), they have up till now received less attention. Tsoukas' (2009) dialogical perspective to theorize productive-dialogue, or a relational engagement, connects dialogical interactions to human cognition. This theorization sheds useful light on the role of dialogical

mechanisms in generating new ideas, or exploration. Yet, we inadequately understand their role, if any, in translating ideas into a concrete form, or exploitation; the latter being an important OKC dimension (Von Krogh, Nonaka and Nishiguchi, 2000). Moreover, while the need to view dialogical mechanisms in relation to a common object of activity has been highlighted (Paavola and Hakkarainen, 2005; Blackler, 2004), they remain to be understood in relation to the task of progressively building new knowledge; how they operate, how they aid movement, how they function and how they affect the knowledge being built. Addressing these gaps requires an appreciation of dialogical mechanisms along the knowledge building task, e.g. developing technological innovations. Doing that is vital, given the importance of dialogue in OKC and in innovation (Frow *et al.*, 2015; Pascal, Thomas and Romme, 2013).

This paper explores the patterns of dialogical mechanisms along 5 overlapping front-end OKC stages – inception, assessment, expansion, refinement and crystallization – adapted from Akbar, Baruch and Tzokas (2018). The paper asks how dialogical mechanisms contribute to building innovations along the front-end OKC stages and whether there are any patterns which could shape our theoretical and managerial understanding of these mechanisms in creating new knowledge. Using 11 qualitatively studied technological innovations and 40 semi-structured interviews the paper aims to develop a framework of the dialogical mechanisms of OKC in the context of the technological innovations' front-end.

The paper contributes to the OKC literature a unique framework of the dialogical mechanisms of OKC in the study's context. The framework unearths two types of dialogical mechanisms – expansionary and contractionary – not distinguished before, which together create new knowledge by operating along the OKC's exploration and exploitation dimensions, respectively. It also distinctively sheds new light on their contrasting roles (progressive vs. restrictive), functions (stimulating vs. delimiting), and effects (expansive vs.

narrowing) not illuminated before. Hereafter, the paper first discusses its definitions and the context, i.e. the technological innovations' front-end, followed by its theoretical basis, i.e. the OKC theory. Next, the paper discusses its focus, i.e. dialogical mechanisms, and critically reviews the OKC literature to identify the gaps. The paper then presents the methodology, and thereafter develops the framework. Finally, the paper states its contribution, implications, boundary conditions and future research directions.

Definitions, concepts and the context

Organization knowledge creation is the process of making available knowledge created by individuals, amplifying, or expanding, it in social contexts, and selectively connecting, or aligning, it to the existing knowledge in the organization (Nonaka and von Krogh, 2009). The OKC process is a social construction (Nonaka, von Krogh and Voelpel, 2006; Von Krogh, Ichijo and Nonaka, 2000), involving: a) the interactions, e.g. between the social context's members, or the agents; which b) progressively build new knowledge, or the object, within an organizational context. Interactions involve conversations and negotiations, among others. While conversations exchange information/knowledge, negotiations try to reach a mutual settlement between the members' varied, and often conflicting, interpretations, or how things are viewed (Nonaka, 1994). Running alongside interactions is the knowledge building process, i.e. the progressive, or gradual, construction of new knowledge out of bare bones. This process under imperfect information/knowledge conditions is dynamic, or evolving. It also involves two conflicting dimensions; generating ideas, or exploration, and translating ideas into a concrete/explicit form, or exploitation (Grant and Baden-fuller, 2004; Von Krogh *et al*., 2000). Knowledge building also occurs within an organizational context which

provides the prospects and opportunities, and, yet, establishes the boundaries and limits to OKC, based on the constraints due to time, resources, market and technology, among others.

Technological innovations are important, constructed outcomes of OKC (Lavie and Drori, 2012). They are the 'innovations [products, services and processes] initiated by use of technology [techniques, tool, equipment, system or knowledge]; they are often associated with the opportunities available to the organization as a result of advances in technology' (Rowley, Baregheh and Sambrook, 2011, p. 76). Technological innovations are risky and complex to develop, and, thus, are developed through a multi-stage process (Baregheh, Rowley and Sambrook, 2009) and through complex interactions between agents with common as well as conflicting interests/concerns (Kazadi, Lievens and Mahr, 2016). Critical to developing technological innovations is the front-end, i.e. the activities prior to the product/service's formal development (Cooper, 2008). The front-end typically involve stages, such as inception, or idea generation, assessment, or evaluation, development, e.g. technical/market feasibility, and crystallization, or defining/shaping, culminating in a concrete, or well-defined, concept (Verworn, Herstatt and Nagahira, 2008). The front-end crucially determines if the innovation merits further investments (Cooper, 2008), and the quality of interactions at the front-end is vital for project success (Brentani and Reid, 2012). Yet, the front-end is fuzzy and less understood (Verworn *et al.*, 2008), and, thus, warrants attention. Given this context, the paper now presents its theoretical basis.

Organizational knowledge creation theory

Instead of the consequential logic, or preference-driven behaviour, the OKC theory follows the logic of appropriateness, i.e. situation-driven behaviour, emphasizing emergence and

discovery. This is because the goals of knowledge creation are usually intangible and fuzzy (Kao, Wu and Su, 2011). The OKC theory centralized the notion of tacit knowledge as the key to creating new knowledge (Nonaka and Takeuchi, 1995). Unlike explicit, or codified, knowledge, tacit knowledge is person-embodied and difficult to articulate, and thus is best transferred when shared (Lam, 2000; Nair *et al*., 2018). This inevitably emphasized the importance of interactions, from which knowledge creation cannot be disconnected. Nonaka's (1994) seminal work modelled these interactions vis-à-vis developing innovations in terms of four knowledge-conversion modes; tacit-to-tacit to generate new knowledge (e.g. an idea), tacit-to-explicit to develop/crystallize the idea, and explicit-to-explicit to connect/align the idea (also explicit-to-tacit to internalize learning). Yet, over the years in the OKC literature, the interactions have taken a life of their own and have been theorized per se; e.g. between individual/social and implicit/explicit knowledge (Spender, 1996), between knowledge and knowing (Cook and Brown, 1999), within knowing-in-practice (Orlikowski, 2002) and between action-mimicking and action-substitution (Ribeiro and Collins, 2007). Despite generating scholarly insights, these theorizations have largely disconnected interactions from the knowledge building task, which effectively annuls the theory's original emphasis on viewing the two conjointly. The knowledge building task cannot be ignored because it is what interests managers most and is what ultimately creates value for the organization.

This paper approaches interactions as mechanisms. Mechanisms are the set of interacting parts that together perform a particular task or produce an effect not inherent in any of them (Hernes, 1998). Their inner working is a natural, expected, process by which something takes place or is brought about; yet they involve an abstract, dynamic logic by which the reality they depict can be understood. Interactions are complex social phenomena which may not have a direct linear relationship with technical problems. Approaching

interactions as mechanisms reconciles them with the level of technical task, which could help in understanding how they operate and function, and under what circumstances (Astbury and Leeuw, 2010). Now the paper's focus, as explained below.

Dialogical mechanisms of organizational knowledge creation

Dialogue is a sustained collective enquiry into the processes, assumptions and certainties, which compose everyday experience to fulfil a collective goal (Issacs, 1993). It represents a divergent, or expansive, conversation, involving multiple perspectives/opinions, unlike a convergent, or narrowing, conversation to achieve closure (Ellinor and Gerard, 1998). Dialogical mechanisms are rooted in the Bakhtin's tradition, and generate meaning, or the way things are or should be, through a dynamic interplay between the opposing voices, affecting and creating each other (Morin, 2007). Interplay is the simultaneous recognition of both the contrasts and connections between viewpoints, perspectives and assumptions (Bligh and Hatch, 2011). Whereas dialectical mechanisms synthesize, or resolve, the thesis-antithesis antagonism by combining contradictory components, dialogical mechanisms only overcome, but not resolve, this antagonism (Costanzo and Di Domenico, 2015). This is because the tensions between voices are an everyday, never-ending series (Hargrave and Van de Ven, 2006), and the voices exist through their complementarity-antagonisms (oppositions) and productive-(inter)play (Morin, 2007). Instead of (either-or) dualism, dialogical mechanisms involves duality (both/and) where the opposing forces act simultaneously on the same phenomenon (Schultze and Stabell, 2004). Innovation occurs when the voices adopt different strategies to deal with tensions (Hargrave and Van de Ven, 2006). Dialogical mechanisms are important to study in OKC because they create value for an organization

from the ongoing dialogical and recursive relationship between, e.g. agents-object or self-others (Costanzo and Di Domenico, 2015).

Dialogical mechanisms are important in knowledge creation (Tsoukas, 2011; Schultze and Stabell, 2004). They have been duly attended to in the learning literature, such as in terms of education (Wegerif, 2013), expansive learning (Engeström, 1991, 1993) and transforming collective habits (Lorino, 2015). Yet, in the OKC literature, while dialectical mechanisms have received considerable attention (Nonaka, Toyama and Konno, 2000; Nonaka and Toyama, 2002, 2005), dialogical mechanisms have not. Tsoukas (2009) is an exception. This study adopts a dialogical perspective to theorize productive-dialogue, or a relational engagement, on an issue causing tension. Productive-dialogue, mediated by interactions, enables distenciation, or reflection, and creates new knowledge, or new distinctions, via conceptual-combination, -expansion and -reframing. This theorization usefully combines dialogical interactions with human cognition, which Paavola and Hakkarainen (2005) in the learning context would regard as the dialogical and monological combination, respectively. It also sheds valuable light on the role of dialogical interactions in generating new ideas, or exploration. However, two gaps remain in our understanding. Firstly, OKC not just involves exploration, but also exploitation (Grant and Baden-fuller, 2004; Von Krogh *et al.*, 2000), and we inadequately understand the role, if any, of dialogical mechanisms in the OKC's latter dimension. Secondly, Paavola and Hakkarainen's (2005) knowledge-creation metaphor (or the trialogical approach) emphasizes the need to systematically view dialogical interactions in relation to a common object of activity (see also Blackler, 2004). Yet, the dialogical mechanisms remain to be understood in relation to the task of progressively building new knowledge. We only broadly know that dialogue is instrumental in generating, developing and crystallizing new knowledge (Nonaka and Takeuchi, 1995). What we understand less are

the operation, function and effects of dialogical mechanisms along the knowledge building process. These gaps are not addressed by Nonaka's (1994) model because its knowledge-conversion modes mask the dialogical mechanisms. Nor are these gaps addressed by any other OKC study. Addressing these gaps requires an appreciation of dialogical mechanisms along the process of building new knowledge, e.g. developing technological innovations.

Recently, Akbar et al. (2018) in modelling feedback loops, patterned five overlapping knowledge-conceptualization stages; generation, evaluation, expansion, refinement and crystallization (differentiation and integration). These are adapted to reflect a typical front-end journey; knowledge-inception, -assessment, -expansion, -refinement and -crystallization. As Akbar et al. suggest, inception and expansion represent exploration as they generate new ideas, whereas assessment, refinement and crystallization represent exploitation as they translate ideas into concrete outcomes. The overlaps between stages reflect four interfaces – inception-assessment, expansion-assessment, expansion-refinement and expansion-crystallization. Resonating well with the overlapping view of innovation stages (Cooper 2008), this paper uses these five front-end OKC stages and their interfaces to explore the patterns of dialogical mechanisms. With the aim of developing a framework of the dialogical mechanisms of OKC in the context of the technological innovations' front-end, this paper asks the following research questions:

- how do dialogical mechanisms contribute to developing innovations along the front-end OKC stages; and
- whether there any patterns which could shape our theoretical and managerial understanding of these mechanisms in building new knowledge.

Methods, data and analysis

Approach and methods

Owing to the exploratory nature of its research questions, this study used a qualitative methodology, involving semi-structured interviews. The unit of analysis was the innovation (henceforth project) at its front-end, and the level of analysis was the innovation team's dialogue. Ethnography (lived-experience) could not be used because the projects involved sensitive (e.g. patent-related) information and thus were difficult to access before completion. The data were collected based on the reconstructed events, an approach which others have also used (e.g. Bosch-Sijtsema *et al.*, 2011; Yakob, 2015). To ensure the reconstructions' accuracy, the study used the within-method triangulation, or using multiple techniques within a method (Jick, 1979), in that across projects it asked similar questions and within a project repeated key questions to cross-check the information. Almost half of the information was cross-corroborated, which Merriam (2009) would regard as a credible criterion.

Research projects

Eleven UK-based technological innovations were studied, as detailed in Table 1. The projects were initially identified if they had gained media publicity or had won any award, and their innovativeness was further established from the interviews. While Project 11 was a straight-forward extension of existing knowledge, other projects were innovative, e.g. difficult to achieve and/or different from the existing products/services. The projects were included until

saturation, where nothing new was discovered (Strauss, 1987). Projects were conceptualized over a six- to twelve-month period. Projects included products (projects 2, 3, 4, 6, 7, 8, 9 and 11), service (Project 1) and processes (projects 5 and 10). They involved varied technologies; biotechnology/biomedical (projects 2, 5, 9, 11), computer (projects 1 and 7), plant sciences/microbiology (Project 3), applied Physics (Project 6), food safety (Project 4), textile electronics/nanotechnology (Project 10) and microelectronics/materials (Project 8). One organization was small-sized (0-9 employees), four were medium-sized (50-249 employees), and six were large-sized (> 250 employees). The participants were mostly aged > 30 (~ 60%) and male (~ 73%), and had associated technical expertise (Project 1 had three non-technical (library sciences) participants). The projects' outcomes included a research publication (projects 5, 8 and 10), a patent application (projects 2 and 6, also Project 8), funding bid (Project 1), product (projects 7 and 11), and a presentation for a prestigious competition (projects 3, 4 and 9).

Data collection and analysis

The participants were the innovation team members. The study conducted 40 semi-structured interviews, including 4 repeat interviews and 3 follow-up interviews. Thirty-two interviews were face-to-face, others were Skype or telephonic interviews, and 35 interviews were audio-recorded. Following Strauss (1987), the interviews started with the research aims/objectives and project description, and then focused on how the knowledge originated, how it was carried forward, how it was developed and how it was crystallized, and the aims, interactions and outcomes thereof. Follow-up questions focused on the disagreements/conflicts, and how these were addressed. The interview duration was ~ 60 minutes on average. Interview transcriptions

(486 pages) were validated by the participants. Field notes recorded observations and insights. Before the data collection, the study was piloted in 4 other projects.

Following Strauss (1987), the data analysis started with open coding through line-by-line analysis to generate free nodes on the interactions, aims and outcomes. Next was the focused coding for the core-categories, or the stages' interfaces – inception-assessment, expansion-assessment, expansion-refinement and expansion-crystallization. The expansion-assessment and expansion-refinement were analyzed together because both developed new knowledge. Next, the analysis identified the incidences of dialogue using content analysis which allows confirming evidence from a large volume of text (Elo and Kyngäs, 2008), using the words which appear in the text directly (or the manifest-content) as well as the meaning of the texts (or the latent-content) (Esterberg, 2002). The analysis used search terms, such as disagreement, opposition, conflict, argument, dispute, dissent, row, split, division, debate and dialogue. For the meaning of the content, the analysis re-analyzed all responses to identify the incidences of dialogue. The analysis then focused on the dialogical mechanisms, based on if a dynamic interplay took place between opposing voices (as opposed to a synthesis, or resolution). The analysis also paid attention to the intensity of opposition, based on the words and the tone of voice used. For example, words like 'no advantage', 'didn't like', 'not keen' and 'difficult to sell' indicated a lower (mild) intensity, whereas words like 'miles apart', 'huge row', 'waste of time', 'outrageous', 'sceptical', 'highfalutin', and 'trouble-maker' indicated a higher intensity. The analysis iteratively involved pattern matching, comparing categories, collapsing categories and data display (see Eisenhardt, 1989), and this continued until saturation, where the existing patterns were no longer refined or disputed (Strauss, 1987).

Table 1: Description of Technological Innovations Studied

Project	Salient Details	Team Size (Interviews)
Project 1	A new, cutting-edge ICT project in the public sector to provide internet access to the public and network 49 libraries across a large UK County. This large-scale project was difficult compared to existing skills and required a radical cultural change in the way librarians traditionally functioned.	Five members (nine interviews)
Project 2	A new, research-based, biotechnology innovation which offered a user-friendly allergen test for dust mites for allergy sufferers. It enjoys two 20-year patents, one for the chemistry and the other for the delivery device – the latter being its USP.	Two members (two interviews)
Project 3	An innovative idea which, using the organization's existing patent, genetically modifies grass to grow to a defined height. It won the UK Biotechnology and Biological Science Research Council's Young Entrepreneurs Scheme Award, particularly for its application to the golf-course industry world-wide.	Four members (five interviews)
Project 4	An innovative idea, winning the UK Biotechnology and Biological Science Research Council's Young Entrepreneurs Scheme Award. It uses friendly (probiotic) bacteria to target 'superbug' (or MRSA) and poultry respiratory tract infections which taken together have a market size of $4.5 billion.	Four members (five interviews)
Project 5	A chance-discovery on one particular (Bcl-xL, cancer protection) gene getting modified to cause tumor. The breakthrough discovery was published in a leading refereed journal.	Three members (three interviews)
Project 6	A chance-discovery, enjoying a 20-year patent, and winning the EU's Descartes Prize. The breakthrough discovery is most likely to replace the $100 billion liquid crystal display industry internationally.	Three members (four interviews)
Project 7	A research-based innovation, winning the Royal Television Society and British Computer Society awards. It uses virtual human technology for motion capture and its translation into sign language.	Three members (three interviews)
Project 8	A microscopic, low-cost and reusable, pen, which combines nanophotonics with ultra-high-resolution inkjet printing and deposits ultra-small ink droplets onto photonic crystals to create new applications and patterns. The innovation is being patented and has resulted in a refereed journal publication.	Two members (two interviews)
Project 9	An innovative idea which uses a chemoattractant to remove a parasite-mite responsible for causing the collapse of the honey bee population. The idea received the UK Biotechnology and Biological Science Research Council's Young Entrepreneurs Scheme Award for its innovativeness.	Four members (three interviews)
Project 10	A novel method for producing conductive cotton fabrics using graphene-based inks. The idea is being patented and was published in the journal Carbon. It has the potential to open up new applications for wearable/flexible electronics, avoiding expensive and toxic processing steps.	Three members (two interviews)
Project 11	A novel, inexpensive diagnostic test which helps to eliminate the African sleeping sickness disease. The project was funded by the national medical research council and a private sector organization.	Two members (two interviews)

Using the standard cross-case analysis techniques (e.g. Eisenhardt, 1989), the projects were compared to identify similarities and differences. In spite of the plurality of interactions, the substantive patterns of dialogue were similar, and the differences were mainly in the extent, frequency and plurality of issues. The analysis also generated 9 procedural memos on categories' properties and exclusion/inclusion of codes and 23 analytical memos on initial insights and patterns, qualifications and research directions. The latter were particularly helpful during the analysis process. The discussion below develops a framework of the dialogical mechanisms of OKC.

Developing a Framework of the Dialogical Mechanisms

The findings below, firstly, discuss the patterns across projects, followed by how the dialogical mechanisms built new knowledge. The discussion is organized along the stages' interfaces.

Inception-assessment interface

Inception explored new ideas and assessment evaluated if they were worthy to be developed further. Their interface involved issues of tension. The most frequent issues were the idea not being exciting/useful and being too ambitious/unrealistic. Issues were not highlighted in projects 6 and 8, and were few in projects 5 and 10. Projects 5 and 6 involved chance discoveries and thus had no other ideas to develop, and projects 8 and 10 involved technologies developed organically by the teams and the teams had fairly good understanding of what they wanted to develop. Conversely, issues were highly diverse in Project 9; yet, this

project involved less dialogue compared to projects 1, 2 and 4 where issues were moderately diverse but the incidences of dialogue were high. The diversity of issues was not related to the project's nature. For example, projects 11 and 7 both involved equally diverse issues; yet, the former was least novel and the latter was highly novel. The analysis then turned to the dialogical mechanisms.

The dialogical mechanisms indeed involved the interplay between thesis (e.g. an idea) and antithesis (e.g. opposition), reflection and affected/created voices:

> One idea was to use…probiotics… we thought that was a pretty good product…we [then] spoke to a guy that works at GGGG… the company is set up to commercialize science… he wasn't very keen… his main concern [was] that the various components you'll need to realize the product that is too diverse… We would need to get a lot of expertise from different fields… And therefore, your margins at the end would be disappearing… we took that on because this guy seemed to know what he was talking about… And it later became apparent that what this guy was saying was virtually always true… (Project 4, Interview 2).

Nonetheless, two sets of dialogical mechanisms were found. The first set mainly focused on the objective of generating ideas: '…a lot of the dialogue initially was about the ideas, and getting a good idea and streamlining that idea…' (Project 3, Interview 4). The dialogue here stimulated creativity and explored new ways of dealing with the tension involved: '…I mean NN wanted to go for the safe area… we take a sample, we test it in test tube, it gives you a colour change' whereas '… I was saying, well, if we go forward with that, there is no advantage with that because that's what everyone else does. So we need to be a step ahead of them…' and '… So we went through the process of trying to find out what may be the way…' (Project 2, Interview 2). See Table 2 for another example. As a result, the dialogical mechanisms generated new ideas:

> YY came up with the original idea. She said wouldn't it be good to be able to spray Staphylococcus Aureus… Well, my thought was that that's fantastic idea but you're never going to get away with spraying Staph Aureus. So why don't you put probiotics in there instead. So, that was the way really that whole product came from (Project 4, Interview 2).

These findings suggested that the dialogical mechanisms in this set functioned by stimulating creativity, and their effect was expansive because they generated new ideas. Thus, they were termed as the *expansionary* mechanisms.

Table 2: Representative Examples of Dialogical Mechanisms

Inception-assessment Interface
Expansionary (stimulating creativity): we sat one lunchtime, just to discuss the ideas... very quickly dismissed all 5 ideas... but doing that actually was a good thing, because it showed the team that we could bring any idea… no matter how ridiculous, and discuss it, and not be embarrassed to do that... then other people started bringing ideas forward… (Project 4, Interview 1).
Contractionary (delimiting new knowledge): [the partner]… put on the table what he wanted. What his problem was, what his ideal solution would be… at a later meeting… we sat down and discussed how you might actually do this practically. Because obviously what he wanted and what we could provide were miles apart (Project 7, Interview 3).
Expansion-assessment/refinement Interface
Interplay affecting/creating voices: … YY very much liked the spray, I very much liked the other delivery method… we debated it over lunch, which would be the best method… we decided that actually we'd think it over, now that we'd heard both sides of the debate… I came away from that initial meeting, very much adamant that my… the wall spray idea was the best… But going away and spending some [time]… I actually thought about it and I completely changed my view (Project 4, Interview 1).
Expansionary (creative thinking/ideas): I am constantly being forced [by opposition] to being educated by other ways of looking at things… when you look at a problem from many many directions, you can get an insight… get passed the blockage of… your imagination… preconceptions that caused you to stop moving (Project 6, Interview 1).
Expansionary (advancing a new direction): …our products that we'd created were only going to be used… for the human use within hospitals. He suddenly came along and said, actually, can you not [instead] use this technology outside of the humans, i.e. in an animal... he'd recently read the regulation where they were cutting down antibiotics in foods, of animals, particularly, animal feed… So he said why can't you use the same technology in chickens, and that was great, that was fantastic, because that provides us with a new direction (Project 4, Interview 1).
Contractionary (eliminating unworkable ideas): GG and I would throw ideas at him and he would say that's impossible, that is possible if we do it this way. So it sort of bring us back down to earth and make things happen (Project 1, Interview 1).
Contractionary (deleting one option in favour of another): …I was suggesting that we could print out the structures and PPP in fact came up with bizarre ideas… PPP was not keen on exploring this… but then I think JJ was crucial in that… essential in pushing… us going in that direction. Having 2 people like us supporting 1 idea against 1 either… people part ways or then out of majority decision that things will go in the way that the majority is proposing… out of the JJ's like supporting the idea that even the alternative work would lead to an important qualification, convinced PPP that it was worthwhile spending doing more experiments for Plan B… (Project 8, interview 2).
Contractionary (deleting one option in favour of another): … the big question was shall we try to really make everything out of this new Nano material… or… rely on what's already there… [I] said the impact is going to come from… a new platform… pick[ing] up what's already out there … that's not really an impact… it's just incremental… On the other side [students]… it was a discussion with them and I said, no, I mean if we don't do this there's no point to even talk about a good paper… that's what a supervisor should do, has a role also in this because you know students sometimes they fail to see the big picture… (Project 10, Interview 1).
Expansion-crystallization Interface
Expansionary (adding to new knowledge): And, you know, without exception everyone's slides changed because, you know, there was input from the whole team. They were saying, well, why did you put that, you should put something else (Project 4, Interview 2).
Contractionary (closure): I was called really quite towards the end… Because he [our manager] felt that they [the team] were full of ideas, but weren't actually moving forward. They were continually discussing new ideas, sort of going up and up on their own fancies and so on, but there wasn't anybody amongst them who perhaps was making them come to conclusion. And, I was seen as somebody who was, as I said to you before, I was more the sort of, let's get this job done (Project 1, Interview 2).

The other set of dialogical mechanisms also involved voices interplaying, but functioned differently and had different effects compared to the previous set. It often involved the tension between creativity and practicality, where dialogue focused less on generating ideas, but more on eliminating ideas: 'But while we were encouraging people to think more and come up with ideas we as team would eliminate wrong ideas' and 'So it was kind of a thinking division style as a mixture of creativity and critical analysis where we would criticize ideas by trying to think down-sides of it' (Project 3, Interview 5). The dialogical mechanisms here fitted new knowledge with what the organizational context allowed. For example, the new knowledge was fitted with the available technology (see quote in Table 2), as well as was delimited to make it realistic:

> … my scepticism on those aspects quite early on was influential, I would claim I think they brought back from the brink of making two outrageous claims of what might be achieved and how, how good things were with, all, all of this (Project 7, Interview 2).

These findings suggested that the dialogical mechanisms in this set functioned by eliminating ambitious ideas and delimiting new knowledge, and their effect was narrowing because they fitted new knowledge within the organizational boundaries, e.g. limits to time/technology. Thus, they were termed as the *contractionary* mechanisms.

Overall, at the inception-assessment interface, the findings suggested that the dialogical mechanisms could be expansionary and contractionary. The expansionary mechanisms by stimulating creativity operated along the OKC's exploration dimension and by generating new ideas played a progressive role, i.e. moved knowledge building forward. In contrast, the contractionary mechanisms by eliminating ambitious ideas operated along the

OKC's exploitation dimension and by delimiting new knowledge played a restrictive role, i.e. restrained knowledge building. Next was the expansion-assessment/refinement interface.

Expansion-assessment/refinement interface

Expansion amplified new knowledge, e.g. added new applications, which were then assessed, and refinement eliminated unworkable ideas and aligned new knowledge with the organizational context. Assessment also occurred at the expansion-refinement interface. These interfaces involved issues of tension. The most frequent issues involved competing options and the application limited by the material's properties. Issues were less diverse in Project 7 perhaps because the team had the necessary expertise to develop the new knowledge further. Contrastingly, issues were highly diverse in Project 1 perhaps because the non-technical team members were frequently opposed by the technically trained team members. Other than Project 1, the incidences of dialogue were also high in Project 4 despite the fact that it reported moderately diverse issues. The diversity of issues was not related to the project's nature; projects 8, 10 and 11 involved equally diverse issues, and, yet, Project 11 was least novel whereas projects 8 and 10 were novel.

The dialogical mechanisms were frequent because the new knowledge had to be developed in detail: '… lots of dialogue… when you develop a lateral flow test there's quite a bit of optimization… they couldn't afford to do the absolutely massive dense range of optimization…' and 'we had to therefore make some choices about what parameters we could afford to explore and that required quite a lot of discussion about technical issues…' (Project 11, Interview 2). The dialogical mechanisms again involved the thesis-antithesis interplay which affected/created voices, see the following response (Table 2 gives another example):

> The original ideas usually came from HH and me talking together… then taking of an idea to poor old MM, and who would often either completely talk us out of it coz it is unrealistic or say, yes, there is some mileage in there. MM was always be the… realistic one… So that were the processes, sometimes our ideas weren't realistic and they couldn't be driven through… (Project 1, Interview 4).

Again, two sets of dialogical mechanisms emerged. The first set focused mainly on exploring ideas, e.g. to develop new knowledge further; '… other parts of dialogue were on mechanics of what we are going to do and how we are going to do that…' (Project 6, Interview 2). The dialogue here stimulated creative thinking and explored new ways of dealing with the tension involved, see the response below (Table 2 gives another example):

> … I would take to him and say why don't we do on-line voting tomorrow. And, he'd say well it's possible to do this, but these are the problems that you come across... So when they let us know that they were not doable, we would say let's find a different way of doing it… (Project 1, Interview 4).

As a result, the dialogue advanced new directions (see Table 2 for an example) and generated new ideas:

> At all point, we'd been talking to manufacturers. Because it was important to get their feedback… to say this is impossible to manufacture, you never got it, do it by this particular design… they developed [the product] further, because then they had ideas from designers… Again bit of creativity came from that. So we, our initial thoughts were completely different to what they saw for the product (Project 2, Interview 2).

These findings, similar to the previous interface, suggested that the dialogical mechanisms here were *expansionary* because they functioned by stimulating creative thinking, and their effect was expansive, in that they advanced new ideas/directions.

The other set of dialogical mechanisms also involved voices interplaying, but functioned differently and had different effects compared to the previous set. This set often involved the tension between creativity and practicality, and the dialogue here focused mainly on assessing if the ideas were realistic. For example, one participant informed that some team members were creative, '… but others were good at finding markets…' and 'creative people will have an idea and then others would develop the idea to see if it can be done… what will take to implement it and whether it can be done in the way it is presented' (Project 3, Interview 5). The dialogical mechanisms here aligned new knowledge with the organizational context, in several ways. Firstly, they eliminated ideas not fitting with the organizational constraints, e.g. available resources, see the response below (Table 2 gives another example):

> … the argument started that XX had these wonderful ideas… but they were perhaps a bit too highfalutin for the amount of money that was being offered and what we could realistically implement… It was the ICT people… trying to bring her back… they had the task of actually implementing it. They were perhaps more realistic… they understood better what is possible in the time and with the money… (Project 1, Interview 2).

Secondly, the dialogical mechanisms deleted one idea in favour of another (see Table 2 for two examples). Finally, they pruned new knowledge to make it workable:

> … when we were developing and refining the project we would come up with applications of the idea and then the two of us would conduct experiments, bring back the results to discuss.

> There would then be a dialogue between what could be done and what not. This dialogue would lead to readjustments (Project 6, Interview 4).

These findings, similar to those at the previous interface, suggested that the dialogical mechanisms in this set were *contractionary* because they functioned by eliminating unworkable ideas/options and pruning new knowledge, and their effect was narrowing, in that they trimmed new knowledge to align it with the organizational limits, e.g. resources/time constraints and market requirements.

Overall, the findings at the expansion-assessment/refinement interface maintained those at the previous interface, that the dialogical mechanisms could be expansionary and contractionary, which operated along the OKC's exploration and exploitation dimensions, respectively, and progressed and delimited knowledge building, respectively. Next was the expansion-crystallization interface, as presented below.

Expansion-crystallization interface

Expansion amplified new knowledge, and crystallization, firstly, distributed it into specialized parts (differentiation) for defining/shaping, and, secondly, assembled the parts (integration) into an explicit and coherent form. Their interfaces involved issues of tension. The most frequent issues involved the time/goal constraints requiring closure, followed by the new knowledge not defined/shaped enough. Issues were not reported in projects 7 and 10, but were diverse in Project 1, and also in projects 3 and 4; the latter two projects also reported high incidences of dialogue.

The dialogical mechanisms continued late into the knowledge building process: 'There was ongoing debate within the working group all the way through right up to the time

when the bid was submitted' (Project 1, Interview 1). The dialogue also involved a dynamic interplay between voices: '… Somebody would… try and read one of the bid points… And then we would discuss the interpretation of that. I think it means this, no I think it means that…' and '… we'd discuss or argue… debate, pros and cons, some people play devil's advocate… and in the end we'd agree a common understanding' (Project 1, Interview 6).

Yet again, two sets of dialogical mechanisms emerged. The first set occurred at the interface between the expansion stage and the differentiation. The dialogue here stimulated thinking about how to improve the new knowledge: 'But then there was this incidence where, you know, slightly detracted criticism....on various slides, there was too much text on that, that's not right' and '… then generally, the person, you know, that produced that slide, you know, would probably go away and think about it and then try, try and improve it…' (Project 4, Interview 2). Consequently, the dialogue added more information to the new knowledge (see Table 2 for an example) and advanced new ideas:

> Then we got our users to look at different subjects… they would come and look at our early draft and say no, we want more pictures. That was very helpful as they gave us an outside view on what we were doing… [they] said that we need much, much more pictures. The buttons should be pictures and far less text on the page. You may want to do something quick and visually immediate. So we had to go back to the drawing board and rethink it all… (Project 1, Interview 1).

These findings, similar to those at the earlier interfaces, suggested that the dialogical mechanisms in this set were *expansionary* because they functioned by stimulating creativity, and their effect was expansive, in that they added more information and advanced new ideas.

The other set also involved voices interplaying, but functioned differently and had different effects compared to the previous set. It occurred at the interface between the

expansion stage and the integration. The dialogical mechanisms here functioned in two ways. Firstly, they coherently fitted the differentiated parts of new knowledge. For example, in one incident the project team while putting together the final presentation refused to incorporate one team member's presentation because it was not fitting with the other team members' presentations. The tension was overcome when the individual member reflected and recognized the weakness of his position, and changed his presentation:

> And, another argument, I lose… we divided the presentation. I said what I write…on my own, you write on your own… I wanted to show that I am better. And they show… just against this idea, it doesn't fit, we write in different styles, we can't put it together. I said I can't [change my presentation, but then realize] May be that idea is selfish, it's not sort of team target, so I lose [the argument]… (Project 3, Interview 1)

Secondly, the dialogical mechanisms restricted expansion. The knowledge building process at this stage increasingly faced time/goal constraints: '… we had also this issue of the timing… to get the patent application sent out first and the paper afterwards and so there was a lot of pressure…' (Project 8, Interview 2). This necessitated the need for closure. For example, in Project 1 the team was continually discussing ideas rather than achieve closure. Thus, an individual manager was called to halt the unending expansion of new knowledge (see Table 2 for the quote) and achieve closure:

> So she [JJ] came and organized us… [the project] wouldn't have come together without JJ… when it got to getting the bid in, she was the one who pulled us together and made that thing. The rest of us were too disorganized people to do it… [the participant went on to say] I mean

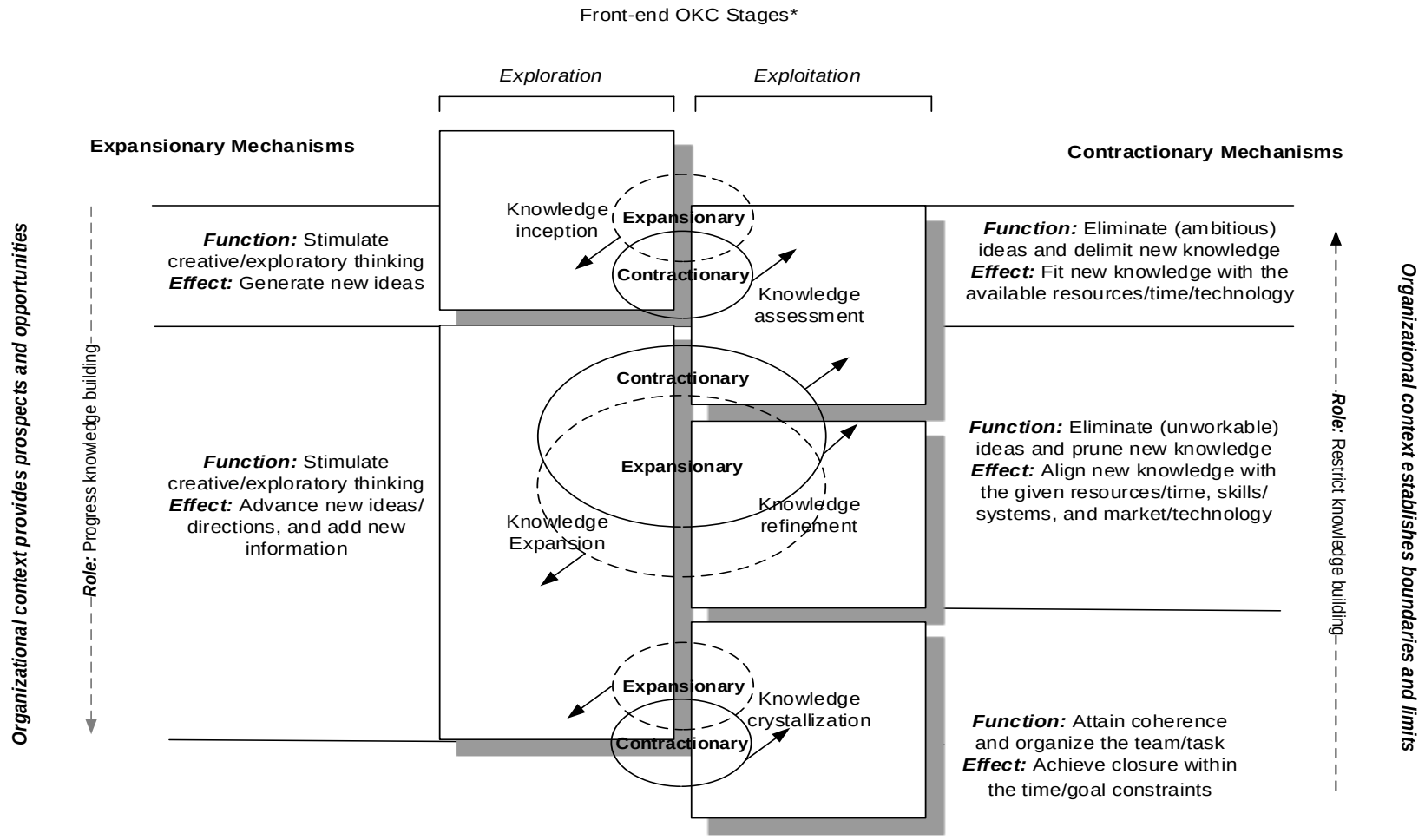
she was very flexible and went with us. But she then brought us back, “You do realize that it is five O’clock and you still have to talk about these things” (Project 1, Interview 1).

These findings, similar to those at the previous interfaces, suggested that the dialogical mechanisms in this set were *contractionary* because they functioned by achieving coherence and organizing the team/task, and their effect was narrowing, in that they achieved closure within the time/goal constraints.

Overall, the findings at the expansion-crystallization interface validated those at the previous interfaces, in that the dialogical mechanisms could be expansionary and contractionary, which operated along the OKC’s exploration and exploitation dimensions, respectively, and progressed and delimited knowledge building, respectively.

Thus, the following framework of the dialogical mechanisms of OKC was arrived at:

Figure 1: Dialogical Mechanisms of Organizational Knowledge Creation (OKC)



* Adapted from Akbar et al. (2018)

Discussion and conclusions

This paper explored how dialogical mechanisms contribute to developing technological innovations along the front-end OKC stages. Using 11 qualitatively studied innovations, the paper developed a unique framework (Figure 1) which distinctively unearths two sets of insights and patterns not captured before. The paper extends Akbar et al's (2018) work on the front-end OKC stages, and contributes to the literature on OKC and dialogue within which the study is framed. Also, the empirical context, i.e. technological innovations, contributes to the literature on knowledge building within this context. These contributions are discussed in turn below.

Theoretical contributions

The paper firstly contributes to the OKC literature by refining our existing understanding of dialogical mechanisms. Indeed, they generate new ideas (e.g. Tsoukas, 2009; Tsoukas, 2011), but that only highlights their role in exploration, and not in exploitation, the latter being an important OKC dimension (Grant and Baden-fuller, 2004; Von Krogh *et al.,* 2000). This paper shows that we only partially understand dialogical mechanisms at present and that they are more diverse mechanisms than are currently understood. They are not unitary, but binary mechanisms, i.e. expansionary and contractionary, which perform differentiated and non-substitutable roles; the former explore, but not exploit, whereas the latter exploit, but not explore. This also balances out their importance in OKC because while each of these mechanisms is necessary, it is not independently sufficient to create new knowledge. They coexist as a duality (Schultze and Stabell, 2004) and operate in unison, proverbially, as 'the accelerator and the break', i.e. to progress and restrict knowledge building, respectively.

The paper secondly contributes to the literature on dialogue by refining our existing understanding of dialogue. Dialogue is mainly understood as a divergent, or expansive, conversation, involving multiple perspectives/opinions, rather than convergent, or narrowing, conversation to achieve closure (Ellinor and Gerard, 1998; also Issacs, 1993). This understanding is valid if the process of dialogue is the focus. However, it is not entirely valid if the focus is on the nature of conversation and its contribution to knowledge building, in that while the expansionary mechanisms are divergent, the contractionary mechanisms are convergent because they narrow down ideas/options and achieve closure. Thus, dialogue takes a new meaning when analyzed in relation to the knowledge building process.

Finally, the paper contributes to the front-end literature in the context of technological innovations. The front-end is an under-researched and less understood phase (Brentani and Reid, 2012; Cooper, 2008; Verworn *et al.*, 2008). Its fuzziness gets compounded in the case of technological innovations because they themselves are complex to develop. Further, their development is typically a social construction (Baregheh *et al.*, 2009; Kazadi *et al.*, 2016), which in itself is a complex interactive process to understand. This paper contributes to reducing this three-pronged fuzziness with a focus on one set of interactive mechanisms and shows how dialogical mechanisms operate and function and under what conditions (see Astbury and Leeuw, 2010; Hernes, 1998).

Managerial implications

The framework which this paper develops is valuable for managers. It allows managers to understand how the expansionary and contractionary mechanisms function along the OKC's exploration and exploitation dimensions, respectively; an understanding which resonates well with the current management thinking. Managers can also recognize their relative

importance; the expansionary mechanisms progress ideas, whereas the contractionary mechanisms fit/align ideas with the organizational boundaries/constraints, and thus both are crucial for creating new knowledge. These insights are important for innovation managers because technological innovations are complex to develop and involve substantial risks for firms. Thus, it is important that innovation managers appreciate how dialogical mechanisms need to be encouraged to successfully develop technological innovations. This paper offers clear pointers for managers aiming to delve into the OKC's dialogical knowledge building journey to create meaningful innovations for the organization.

Boundary conditions and future research agenda

The study is limited to one-off innovations in the UK, nonetheless. The paper proposes two main directions for future research. The first is to examine the frameworks' applicability in other contexts. For example, virtual communities-of-practice would be an interesting research context because such communities often pose coordination challenges for the organization (Driessen, Kok and Hillebrand, 2013). Another interesting context would be idea management, i.e. generating and evaluating ideas (Vandenbosch, Saatcioglu and Fay, 2006). The framework can also be examined in the context of strategy meetings as social practice because they involve both stabilization and destabilization of orientations (Jarzabkowski and Seidl, 2008). While this study focused on the team level dialogue, the framework can be examined in terms of the individual or inter-organizational level dialogue. The second research avenue relates to the power relations which this paper did not cover. The dialogical discourse inevitably involves the link between power and knowledge or its creation (Schultze and Stabell, 2004). Future researchers can thus explore how the two types of dialogical mechanisms associate with the stakeholders' power relations.

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