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How research agendas are framed: Insights for leadership, learning and spillover in science teams

Conor O'Kane [a,*], Vincent Mangematin [b], Jing A. Zhang [c], Jarrod Haar [d]

[a] Otago Business School, University of Otago, Dunedin, New Zealand
[b] ESDES Business School, Catholic University of Lyon (UCLy), Lyon, France
[c] Otago Business School, University of Otago, Dunedin, New Zealand
[d] Massey School of Management, Massey University, Auckland, New Zealand

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ABSTRACT

Research agendas in science are fundamentally important to the generation of new knowledge and innovation. Yet, there remains a lack of scholarly attention and poor understanding on how science teams engage with research agendas in ways that influence their development. New insights are needed to better understand the factors that contribute to research agenda development and adaptation. In this paper, we draw on the framing perspective to explore how research agendas are framed in science teams over time. Research agendas can be understood as collective action frames within science teams that mobilize, guide, and coordinate the transformation of innovative but abstract science aspirations into something more concrete. Our research utilises a longitudinal case study analysis of two science teams over seven years (2016–2022). Our findings provide several new insights. First, we detail two ways in which research agendas are framed. Through centralised framing, research agendas are embodied and dictated by a visionary science team leader. In contrast, through decentralised framing, team leadership is weakly enacted and multiple team members discuss and deliberate the composition and direction of the research agenda. Second, we show centralised and decentralised approaches to framing enable and constrain the reframing and transformation of research agendas. Third, we demonstrate centralised and decentralised framing of research agendas are respectively stabilised by passive and active team learning environments across three areas: research agenda responsibility and accountability, nature of autonomy, and leadership development pathways. Finally, we theorise that, to enhance spillover, leaders who centralise framing of the research agenda need to balance between the benefits of reframing efficiency, and enabling greater team interaction and opportunities for S&T human capital development. On the other hand, when framing of research agendas is decentralised, team leaders need to balance between the benefits of team collaboration and leader development, and path dependent decision making. These insights lead to propositions that offer implications for theory and practice.

1. Introduction

In science, research agendas set prioritised research questions and hypotheses that have significance for advancing and influencing a discipline or field of study. Despite their fundamental importance to the generation of new knowledge and innovation, there remains a lack of scholarly attention and poor understanding on how research agendas are developed.

Research agendas have significant utility in the work of science teams. While our knowledge on science teams has improved across a wide range of areas relevant to research agenda implementation, e.g., division of labour (Walsh and Lee, 2015; Haeussler and Sauermann, 2020), organisational structure (Shinn, 1982), and collaborative dynamics (Porac et al., 2004), missing from the literature are studies that examine how science teams engage with research agendas in ways that influence their development over time. This gap in the literature needs to be addressed to uncover new insights and understanding on the factors that contribute to research agenda development and adaptation, and the challenges teams encounter aligning individual goals and expectations with the collective research agenda.

In this paper, we draw on the framing perspective to explore how science teams frame their research agendas. Frames are interpretive

* Corresponding author.
E-mail address: conor.okane@otago.ac.nz (C. O'Kane).

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schema (Snow and Benford, 1992) that help read and manage ambiguous situations and processes (Walsh, 1995), while the process of framing can be understood as "the use of rhetorical devices in communication to mobilize support and minimize resistance" (Cornelissen and Werner, 2014, p.185). We can think of research agendas as collective action frames (Benford and Snow, 2000) within science teams. They are inherently uncertain processes that play a key role mobilising, coordinating, and guiding the team's transformation of innovative but abstract science aspirations into something more concrete. Utilising a framing perspective allows us to explore the extent to which research agendas are framed top-down (Lee et al., 2018; Snow et al., 1986), through interaction (Reinecke and Ansari, 2021; Gray et al., 2015) and contests (Kaplan, 2008), and relatedly, how the framing of research agendas might be transformed over time (Cornelissen and Werner, 2014; Gray et al., 2015; Reinecke and Ansari, 2021).

To guide our exploration of these issues, our study has two research questions. First, how is the framing of the research agenda within science teams influenced by its leadership? Second, what happens within the science team during the framing of the research agenda? Our research utilises a longitudinal case study analysis of two science teams over seven years (2016–2022). Our case studies titled MED (medical technology) and MMA (additive manufacturing) are funded within NZTI, a New Zealand (NZ) National Science Challenge focused on technological innovation through science stretch research programmes.

Our findings make several contributions through the generation of insightful propositions. First, we add to the literature on research agendas and science team leadership by showing that centralised framing of research agendas is controlled by a visionary science team leader and decentralised framing of research agendas involve team wide interaction and deliberation. Second, we contribute to theory on framing processes and the transformation of frames over time. We do this by showing that the reframing of research agendas is more efficient when centrally controlled, than it is when research agenda framing is decentralised and contested. We also show how the transformation of centrally framed research agendas occurs through leader-controlled separation and spin-off with a new team, while research agenda framing that is decentralised is transformed through a collaborative team-driven spin-off involving several members of the original team. Third, our research contributes to literature on learning and the development of scientific and technical (S&T) human capital within science teams. More precisely, we show how the different approaches to framing research agendas are stabilised by distinct learning environments. On the one hand, centralised framing of research agendas supports team learning when team members require high levels of science guidance and resourcing, but limited research agenda responsibility; high levels of autonomy and freedom to focus on their own science tasks; and the opportunity to observe and work with a visionary leader. On the other hand, decentralised framing of research agendas supports team learning when team members seek high levels of responsibility and accountability for the team's research agenda; high levels of autonomy to collaborate across the team; and opportunities to learn as leaders by stepping into formal leadership roles as the research agenda develops. Fourth, we contribute to literature on spillover and science teams. Specifically, our findings show that different tensions and frustrations surfaced in both teams as their respective research agendas approached transformation and spin-off. Based on these findings, we propose that, in order to enhance spillover, visionary leaders who centralise framing of the research agenda need to balance between the benefit of reframing efficiency and enabling greater team interaction and S&T human capital development opportunities. In contrast, when framing of research agendas is decentralised, team leaders need to balance between the benefits of collaboration, consensus and leader development, and path dependent decision making. We theorise that, if left unaddressed, frustrations and less productive learning experiences among science team members will result in spillover tensions that may compromise the development and diffusion of future science leaders and effective strategies for framing research agendas among the scientific community.

2. Theoretical background

2.1. Research agendas and science teams

The coordination of research programmes in science involves some novel approaches (Franzoni and Sauermann, 2014), however, the production of science by large teams of interdisciplinary researchers remains commonplace (Stephan, 2015; Wuchty et al., 2007). A significant amount of research has been undertaken on how factors related to science team composition (e.g., size and interdisciplinarity, task variety) impact team outcomes such as productivity (Porac et al., 2004; Yegros-Yegros et al., 2015), creativity (Lee et al., 2015), and commercialisation (Kotha et al., 2013; Bercovitz and Feldman, 2011). Scholars have also examined the organisation of work within science teams. For instance, Walsh and Lee (2015) show how the extent of bureaucratic structuring within science teams - division of labour, standardisation (i.e., task specification), formal hierarchy and centralisation/decentralisation of responsibility – is influenced by team size, and levels of interdisciplinarity and interdependence among the researchers. Furthermore, disaggregating the division of labour within science teams to focus on individuals, tasks and interdependencies, Haeussler and Sauermann (2020) offer nuanced insights on how team size and interdisciplinarity are related to the coordination of work within science teams.

Although these studies have significantly improved our understanding of science team organisation and outcomes, it is argued that more research is needed on the operating dynamics within science teams (Hall et al., 2018). One specific operating dynamic that has been overlooked in the literature to date is how science teams collaborate on their research agenda. Despite their omnipresence in the production of knowledge, there is surprisingly little dedicated scholarly attention on research agendas. Drawing on existing literature (Ertmer and Glazewski, 2014) and organisational practice, we define research agendas as problem-solving strategic frameworks that direct and set prioritised research questions and hypotheses, which are informed by gaps in knowledge, and that have significance for advancing and influencing a discipline or field of study. Thus, research agendas provide researchers with both lower-level focus and higher-level guidance, and this focus and guidance adjusts as new knowledge is accumulated. Notably, however, there remains a poor understanding of research agendas and their development within science teams.

While there is a paucity of research on this subject, two studies offer valuable insights. Shinn (1982) explored how social (i.e., authority, hierarchy and communication) and cognitive (i.e., division of labour) configurations developed within three laboratories. Shinn's findings show that the social and cognitive configurations were aligned within each laboratory discipline, and that these produced three distinct research agenda team environments. In mineral chemistry, the research agenda was hierarchical, with an authoritative leader, restricted communication and a clearly structured and mapped out division of labour. The solid-state physics research agenda was less hierarchical with more fluid and distributed leadership, compartmentalised communication, and research tasks that were undertaken in both structured and organic ways. Vector analysis demonstrated what Shinn titled a 'permeable model', where authority was not exercised, there was minimum hierarchy, an abundance of two-way communication exchanges, and flexible self-selection into undifferentiated work tasks. In another study, Porac et al. (2004) explored the collaborative dynamics in two science teams developing separate research agendas related to high performance computing. The focus of this study was to understand how human capital influences the trajectory of knowledge production in science teams over time. Porac and colleagues found that both teams benefitted from the collaboration, but in different ways based on their distinct team compositions and the nature of their research agenda.

More precisely, it was found that one team, whose members had similar disciplinary backgrounds, prior collaborative experience and a research agenda oriented around a strong theoretical paradigm, further enhanced their productive collaborations, but did so in a way that reinforced or incrementally advanced their research agenda. The second team whose members had more heterogenous disciplinary backgrounds, weaker prior collaborative experience and a research agenda based on an emerging discipline benefitted in a more substantial way. Not only did their rate of productivity and collaboration increase more significantly, but they did so in a way that helped to support and develop the emergence of a highly novel research agenda.

These studies provide rare insights on the operating environments and collaborative efficiency of science teams implementing research agendas. However, they do not show how science teams engage with their research agendas and develop them over time. Examining this subject is important as it will uncover new insights on the factors that contribute to the implementation and adaptation of research agendas, and the challenges teams encounter in aligning individual goals and expectations with collective science trajectories. Research agendas are inherently uncertain, they attempt to guide the transformation of innovative but abstract science aspirations into something more concrete. To this end, we draw on the framing perspective to explore how science teams frame their research agendas.

2.2. Framing research agendas

Frames are interpretive schema (Snow and Benford, 1992) that help read and manage ambiguous situations and processes (Walsh, 1995). Framing as a process has roots in impression management, where narratives are used to develop meaning for key audiences (Goffman, 1959). In this paper, we adopt a more recent definition of framing, namely "the use of rhetorical devices in communication to mobilize support and minimize resistance" (Cornelissen and Werner, 2014, p.185). Framing has been used to good effect in studies on multiple topics related to innovation processes, including problem definition (Leonardi, 2011; Vaccaro et al., 2011), new venture creation (Falchetti et al., 2022; Taeuscher and Rothe, 2024) knowledge transfer and collaboration (Van Burg et al., 2013), inclusive innovation (Pansera and Owen, 2018), public innovation (Fuglsang and Hansen, 2022) new technologies materiality and meaning (Bojovic, 2022; Hoppmann et al., 2020) institutional change (Hargrave and Van de Ven, 2006), and the innovative power of networks (D'Andreta et al., 2016). However, to date, research agendas in science development have been overlooked in the both the literature on framing and processes of innovation.

We believe that framing offers a promising perspective for exploring the process of research agenda development. Research agendas represent a collective action frame (Benford and Snow, 2000) within science teams. Focusing on research agenda framing and reframing can provide much needed insight on how science teams are dynamically mobilised (Cornelissen and Werner, 2014) around collective science trajectories as they evolve. Framing may also help to understand how activities and experiences are coordinated (Snow and Benford, 1992) within science teams as collective research agendas are defined and develop. Given the lack of direct scholarly focus on the subject, we can look to literature on social movements to speculate on how research agendas as collective action frames develop over time within science teams.

One perspective, that of top-down framing, highlights the influence of visionary and deliberate framing by key strategic actors, such as leaders, as they attempt to develop collective frames that resonate (Benford and Snow, 2000; Lee et al., 2018; Snow et al., 1986). Parallels here can be drawn with the role of science team leaders in research agenda framing. For instance, in the case of star scientists, a stream of literature reports on their domination of team research agendas, to the extent that it can limit the contribution (Tzabbar, 2009; Tzabbar and Vestal, 2015) and development (Kehoe and Tzabbar, 2015; Li et al., 2020) of other team members. Another stream of literature has examined the role of principal investigators (PIs) as science leaders that shape and manage team research projects and programmes (O'Kane et al., 2015; Cunningham et al., 2014). While informative on the subject of research agendas, both streams of literature stop well short of offering insights or explanation on how research agendas are framed and develop over time. To this end, the first and primary research question of our study asks, how is the framing of the research agenda within science teams influenced by its leadership?

Another framing perspective highlights how collective frames emerge from ongoing interaction and negotiation (Gray et al., 2015). In such framing processes, the emphasis is on the interaction, namely 'meaning making over meaning deployment' (Reinecke and Ansari, 2021, p.379). Moreover, particular consideration is afforded to how frames transform over time as new interpretations form through dynamic interactions (Cornelissen and Werner, 2014; Gray et al., 2015; Reinecke and Ansari, 2021). As an example, framing contests arise when individuals or organisations have incongruent frames related to an issue and take actions to influence how others frame the issue (Gurses and Ozcan, 2015; Kaplan, 2008). Examining strategy making practices within a firm, Kaplan (2008) shows how individuals adeptly engage in framing practices to try and make their framing of a strategic choice resonate and become legitimate with others. When successful, the contest results in the individual's frame becoming the predominant frame within the organisation, that is, it becomes "a guide to actors' positions" on the decision to be made regarding that choice. When contests are not successfully resolved, the divergence in frames creates inefficiencies in decision making. A key insight from the research is how framing contests are influential in determining continuity or change in a firm's strategic development. Although such interactive and contested framing processes are likely to be relevant in the development of research agendas within science teams, we lack insight from the literature on how this may occur. We therefore ask a second research question, namely what happens within the science team during the framing of the research agenda?

In sum, theory indicates that, broadly, framing processes can be more top-down or form organically through interactions (Lee et al., 2018). Our study aims to uncover whether and how these framing processes are employed by science teams when framing and reframing their research agendas over time. We next present our study's research design.

3. Method

Our study adopted a "question-driven" approach (Graebner et al., 2023), which is appropriate when key phenomena of interest remain unexplained in the literature. Specifically, given the lack of extant theory on the framing of research agendas within science teams, our study chose an inductive, grounded theory approach using two longitudinal (seven-year, 2016–2022) case studies (Charmaz, 2006; Edmondson and McManus, 2007; Strauss and Corbin, 1998). Case studies provide in-depth qualitative data that can help to explore the context and identify the tacit complex processes by which teams and team members frame research agendas. Moreover, longitudinal case study data helps to identify and track research agenda framing dynamically and in real time, rather than solely retrospectively (Langley, 1999).

3.1. Research setting

Case study comparisons aid theory development as it affords the opportunity to identify replication or meaningful distinction (Eisenhardt and Graebner, 2007). However, theory building relies on the purposeful sampling of empirical sites that will be informative for the phenomenon of interest (Strauss and Corbin, 1998; Yin, 2009). Our case studies (titled MED and MMA) are two research teams funded within NZTI - a New Zealand (NZ) based National Science Challenges (NSC). NZTI was funded for $106 million over ten years (2014–2024) with an explicit focus on technological innovation through science stretch. For several

Table 1
MED and MMA case snapshots.

	MED	MMA
Duration	2016–2022	2016–2022
Science focus	Type 2 Diabetes: insulin delivery device	Additive manufacturing: 3D/4D printing using biopolymers
Total funding	$5.8 m	$5.5 m
Number of times funded	3	3
Research expertise	Health and medical devices, mechanical/electrical//bioengineering, mobile robotics, computational modelling, and microsystems technology.	Material science, software development, mechatronic and robotics, nanotechnology, product design, 3D printing and nuclear physics.
Num team members (start)	14, 7 established researchers, 4 post-doctorate, 3 PhD	14, 11 established, 1 post-doctorate, 2 PhD
Roles and titles (start)	All academic, 2 Professor[a]	All academic, 3 Professors
Affiliated institutions	2 Universities	8, 5 Universities, 3 Crown Research Institutes - applied industrial oriented research

[a] There was a second Professor listed on the team, but they had passive in-kind involvement. They were interviewed during data collection.

reasons, MED and MMA offer promising empirical cases to explore the framing of research agendas.

First, is the robust longitudinal nature of both cases. Within NZTI, there was recurrent assessment on how all teams were advancing their research programmes. Only those teams that demonstrated acceptable levels of progress following review during Phase 1 funding were refunded in 2019 for Phase 2. Teams also underwent a formal Science Quality and Impact (SQI) review in 2021 in which an external international panel evaluated evidence of current and projected research progress, quality and impact. Furthermore, in 2022 teams were invited to apply for new funding for projects based on science developments within their research agendas - titled Ending with Impact Projects (EWIPs). Commenting on these EWIPs, the NZTI Board Chair stated, "it's vital that every drop of potential impact from our research is delivered". MED and MMA were among the earliest teams formed and they retained funding and were refunded throughout the available funding period (other teams were discontinued). More precisely, both MED and MMA were evaluated as making sufficient progress with their respective research agendas to advance through all the above-mentioned assessment stages, culminating in two EWIPs being funded. This allowed for a seven-year longitudinal study on how two "performing" research agendas were framed over time.[1]

Second, the teams offered variety in terms of distinct areas of expertise and forms of leadership. MED had a high-status star scientist leader while MMA had a shared leadership team of three professors. All other members of the teams were less senior than their respective leaders. Early observations and interviews indicated the case teams offered a promising opportunity to compare leadership influence on the framing of research agendas. Notably, both MED and MMA were formed through mission labs in which cross-disciplinary groups of academic researchers and practitioners collaborated to shape science-stretch research programmes. As explained by the NZTI Programme Director:

> "When we put people together in a room, the question is not 'what are you researching that could relate to this mission'? It's 'what capabilities can you bring'? You want the best people working on the same problem, rather than a collection of folks all trying to get their own pet research project over the line."

Thus, in contrast to investigator-led science projects, the formation and funding of MED and MMA occurred organically, offering a unique opportunity to also examine team dynamics as research agendas developed over time. Table 1 offers a snapshot of the MED and MMA cases.[2]

3.2. Data collection

Data collection utilised multiple qualitative methods (i.e., interviews, observations, team communications and archival documentation) to explore the framing of research agendas within science teams. The use of diverse qualitative data helped us to identify and integrate novel and in-depth insights from our cases (Yin, 2009). Broadly, over seven years we periodically conducted 52 semi-structured interviews with all established MED and MMA researchers. These established researchers represented the core members of the two teams, namely those involved in the original mission lab and who remained part of the teams throughout the research process. Open ended interviews with researchers focused on updates and challenges with their respective research objectives, their thoughts on how the research agenda of the team was progressing, and how they were working with others within and outside of the team. As already mentioned, a strength of our study were the longitudinal interviews which enabled us to identify and probe developments in real time, but also to revisit issues raised in earlier interviews at later stages and across multiple informants. A second strength of our data collection was the periodic observation of team meetings which provided access to unique data. Within these meetings, which ranged from half day to full day in length, extensive notes were taken as team members discussed research progress and challenges. There was also an opportunity at these meetings to ask questions and seek clarification, both formally within the meeting agenda or informally. More generally, our study benefitted from a significant number of informal conversations where we interacted with members of the two case teams at NZTI-organised capacity development events. All interviews and observation notes were transcribed/written up and logged in a shared team folder. A third strength of our study was the extensive secondary material collected and incorporated within the research analysis. This included copies of team presentations (at kick-off and update meetings), milestone progress reports, workplans submitted as part of (re)funding applications, reports from external evaluations of both case teams, email exchanges with or relevant to teams, as well as press/web releases from the NZTI communication team. This secondary material not only provided valuable original data related to our research question, it allowed us to cross-check or extend insights emerging from our primary data. Table 2 provides a summary of the data collected in

[1] Our interest is in research agenda framing and team dynamics in science teams. To study this, we regard continuation in funding over time following rigorous review as an appropriate proxy for research agenda performance. We acknowledge there are many other ways research agenda performance can be evaluated such as publication productivity, co-authorship, network formation, innovation speed etc.

[2] The cumulative size of both teams grew and fluctuated throughout the research window as new and old PhD/Masters students began and completed research work that contributed to the teams' objectives. Our research is primarily concerned with the established researchers on both teams who were there from the outset and remained involved throughout the study period.

Table 2
Summary of data collected and its use in analysis.

Types of qualitative data	N	Use in analysis
Longitudinal interviews	52	Tracking research agenda related developments and challenges. Recording team members' perceived contribution and roles over time.
Observations of team meetings[a]	11	Observing team dynamics and nonverbal behaviour, hearing how research agenda is coordinated and discussions on team resourcing. Seeing prototype trials and hearing/observing reactions.
Informal discussions with team members	~	Seeking clarification on technical aspects of project or thoughts on provisional findings and theoretical insights.
Workplans submitted for (re) funding	7	Tracking research objectives progress/edits/additions and how the research agenda is articulated/modified. Noting team's recorded external engagement activities. Cross-checking insights from primary data.
Milestone progress reports (usable)	6	Tracking research objectives progress/edits/additions and how research agenda is articulated/modified. Noting team's recorded external engagement activities. Cross-checking insights from primary data.
Report findings from external evaluation	1	Noting panel assessment and recommendations of team capacity development, research progress, stakeholder engagement and perceived impact potential of research agenda.
Presentations	5	Updates on research progress. Cross-checking insights from primary data.
Email exchanges (usable)	3	Clarifications on novelty and direction of research agenda, noting reaction to offers of assistance with team's external engagement
NZTI comms team press/web releases	>15	Cross-checking insights from primary data, accessing additional data from (secondary sourced) interviews with team members, accessing up-to-date details on research agendas and broader empirical context.

[a] Observations of team meetings did not take place during periods of 2020 and 2021 due to lockdowns. Interviews continued online.

our study and how this was used in the analysis and development of theory.

3.3. Data analysis

Two research questions guided our study. First, how is the framing of the research agenda within science teams influenced by its leadership? Second, what happens within the science team during the framing of the research agenda? For clarity, the primary unit of analysis in our study was the research agenda, and our exploration of two core areas of focus related to this (i.e., leadership and team dynamics), while connected through the shared primary unit of analysis, was fully data driven and does not claim causality. That is, we analysed the data inductively, as informed by the approach of grounded theory building (Charmaz, 2006).

Consistent with inductive techniques (Gioia et al., 2013; Strauss and Corbin, 1998), our data analysis involved several stages. The first was provisional open coding, which helped to identify the cases. Following on from this, utilising both longitudinal (Langley, 1999) and thematic (Gioia et al., 2013) analysis, we adopted a '*What*' (Stage 2), '*Who*' (Stage 3), and '*How*' (Stage 4) approach to analyse and compare each case. More precisely, stages 2 and 3, which respectively focused on identifying 'what' occurred with each research agenda over the seven-year period, and 'who' was involved in driving, communicating, and formulating it during this time addressed our first research question. Stage 4, which focused on 'how' team members' experiences and approaches evolved during the corresponding research process, addressed our second research question. Across stages 2–4, we utilised both within- and cross-case comparisons (Eisenhardt and Graebner, 2007) to identify and understand theoretical themes or linkages between leadership and research agenda framing, as well as insights on how dynamics within both teams changed as the research agendas developed. We next describe these four stages.

Stage 1: Our study adopted a processual approach (Langley, 1999), undertaking preliminary analysis as we collected the data. Specifically, the protocol for our social science team was that researchers tracking science teams (like MED and MMA) would upload interview transcripts and notes on a shared Teams folder. Researchers were expected to undertake open coding on these transcripts, broadly identifying what insights they found interesting as they conducted their interviews and attended team meetings. The main purpose of these open coded files was to stimulate discussion at our team meetings - we met face to face three times per year, but many times beyond that online, either in groups or subgroups. It was through this collaboration and provisional coding that we identified MED and MMA as potentially interesting cases on the broad topic of research agenda development.

Stage 2: Primary and secondary data on MED and MMA was analysed for evidence on 'what' the focus, content and objectives of their respective research agendas were, and any changes that occurred in these during the study period. Secondary data including presentations, progress reports and refunding applications were particularly useful for this analysis as they provided clear and formal written details on what was occurring and why. This stage of the analysis was important as it allowed us to temporally bracket (Langley et al., 2013) the primary unit of analysis in our study – the research agenda – into three distinct stages: i.e., 'early one to three years' for initial frame; 'mid three to five years' for reframing; and 'latter post five years' for transformation. This bracketing provided a structure for subsequent stages of analysis, enabling potential replication of theoretical ideas relevant to our questions across the longitudinal process (Langley et al., 2013).

Stage 3a: All primary and secondary data was organised longitudinally, then coded independently by two members of the research team for evidence of leadership framing. By leadership we did not approach the data with assumptions around hierarchical positions. Rather, we coded for evidence of research agenda leadership, that is who across both MED and MMA was talking about the research agenda of the team, with whom were people discussing the research agenda, and in what way were they referring to or communicating the research agenda? After an initial round of open coding, we took broad guidance from the literature on framing. For instance, our coding was informed (but not dictated) by evidence of research agenda contests (Kaplan, 2008); narratives (Cornelissen and Werner, 2014); why- versus how-discussions (Falchetti et al., 2022); and the use of prototype demonstrators (Stigliani and Ravasi, 2018). While lightly guided by relevant literature, a key consideration at this stage was avoiding "theoretical arrogance", namely ensuring informants' voices and interpretations were accurately captured and protected (Gioia, 2021, p.24).

Stage 3b: The researchers undertaking the first-order coding came together regularly to discuss, clarify, refine and consolidate the codes they each identified within both cases, and to discuss their positioning with respect to the research agenda temporal brackets. This was important to capture insights on the framing of the research agenda(s) as a process over time. Gradually, researcher discussions progressed from first order code refinement to second-order thematic (Gioia et al., 2013) or axial (Strauss and Corbin, 1998) coding. More precisely, the researchers 'entered' the analysis as knowledgeable agents (Gioia et al., 2013), iterating abductively between the literature and coded data (Gibbert et al., 2008) to try and identify linkages and patterns and how the first-order codes could be grouped into higher order themes related to leadership influence. According to Gioia (2021), the guiding question for researchers at this stage should broadly be, can my unique point of view see some nascent themes of theoretical relevance that the informants cannot see through their own experience and interpretation? This stage of the analysis resulted in four second order themes being

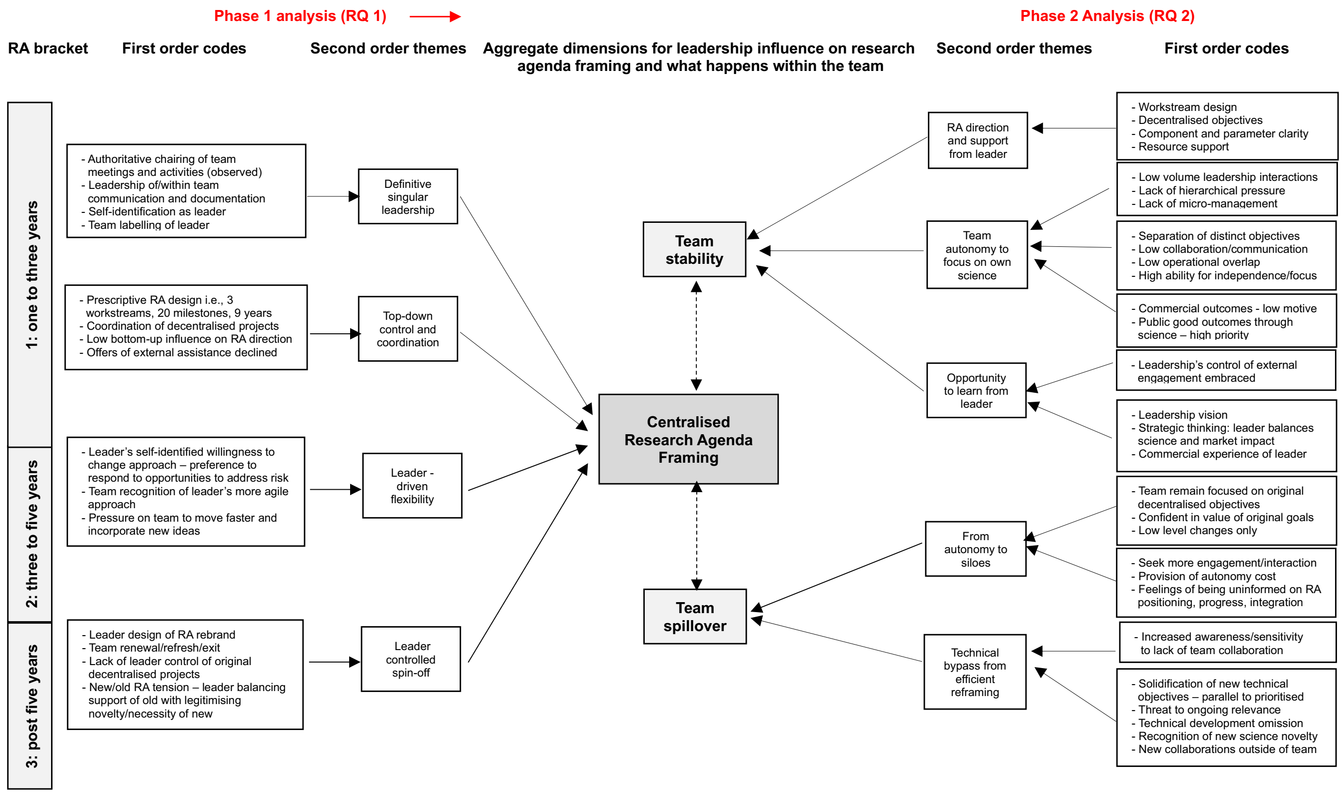

Fig. 1. MED data structure.

identified for both MED and MMA cases.

Stage 3c: The eight longitudinally positioned themes from both cases were examined and discussed by the research team. Two key considerations at this point were first, how the second-order themes could be grouped together in an aggregate dimension *within* each case, and second, how such groupings might compare or contrast across both cases. In essence, an "uncodifiable creative leap" (Langley, 1999, p.691) was required to synthesize the themes and insights developed through

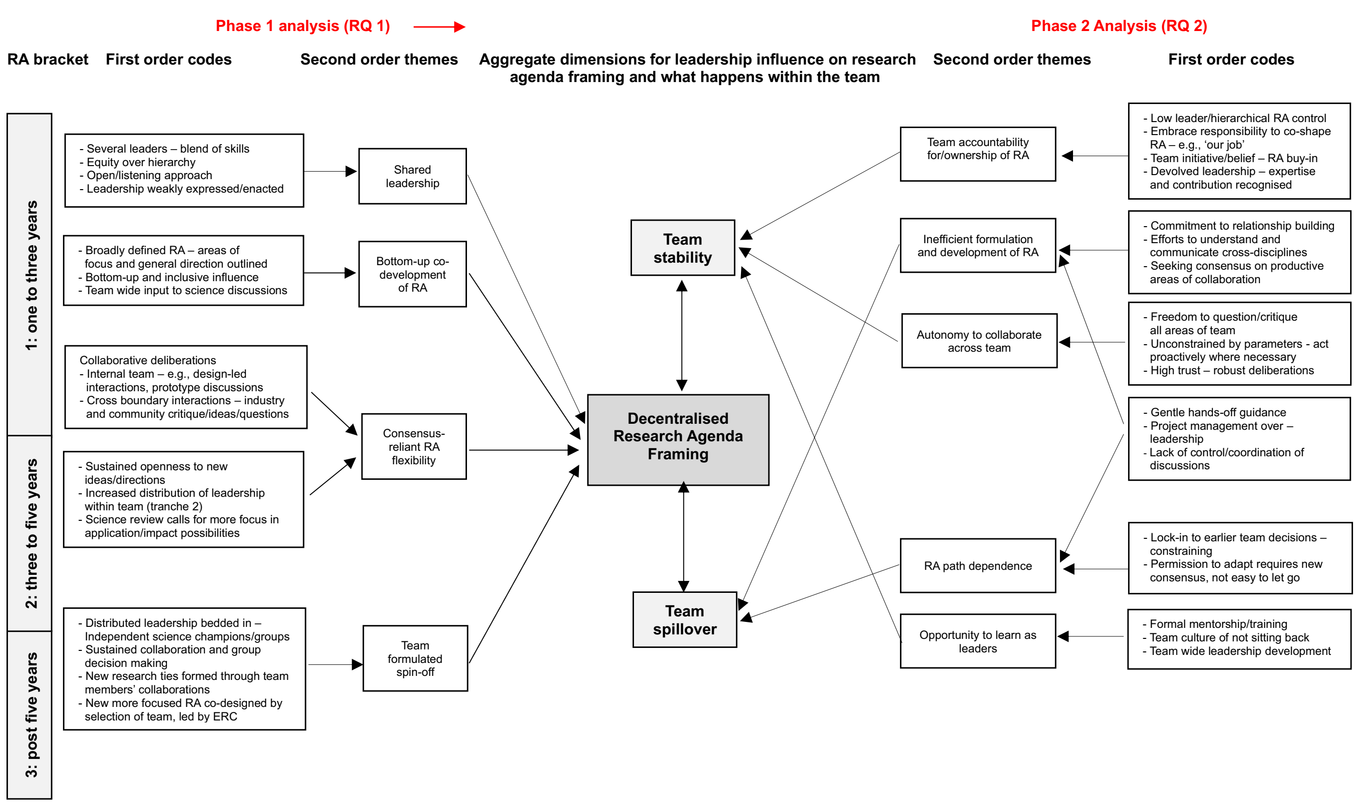

Fig. 2. MMA data structure.

the earlier rounds of coding. The outcome of these discussions and cross-case comparisons was the identification of two distinct aggregate dimensions that offered a processual understanding on how leaders influenced research agenda framing within MED and MMA.

Stage 4: Next two members of the team independently recoded secondary and primary data from both cases for evidence of team member experiences, approaches, activities etc. throughout the research process. Once again, the researchers regularly discussed and refined their codes to eliminate and consolidate overlapping or similar codes (Gioia et al., 2013), and to agree on their positioning against the research agenda temporal brackets. A process of axial coding (Strauss and Corbin, 1998) within and across the two cases eventually resulted in five theoretically relevant themes being identified for MED and MMA. Further discussion and cross case comparison on these second order themes in relation to our second research requestion - what happens within the science team during the framing of the research agenda? - resulted in two common aggregate dimensions being identified within both cases (i.e., 'team stability' and 'team spillover').

The data structures in Figs. 1 and 2 illustrate our overall analysis for both cases, and a "plausible, defensible explanation" (Gioia, 2021, p.27) of how leadership influences research agenda framing, and what happens within science teams as the research agenda evolves.

4. Findings

In the following section, we present findings addressing the primary research question of our study: how is the framing of the research agenda within science teams influenced by its leadership? We provide evidence of two distinct approaches in which research agendas are framed and reframed over time within science teams - 1) centralised framing of research agenda and 2) decentralised framing of research agenda. Fusing contributions of individual researchers from both cases, detailed findings are conveyed below at the collective team level. We provide summaries of these findings in Tables 3 and 4.

4.1. MED's centralised framing of research agenda

Stage 1: From the outset, MED's research agenda was well defined. It focused on developing a point of care needle-free sensing and insulin delivery device for Type-2 diabetes. A point of care non-invasive technology would help diabetic patients more frequently and regularly measure blood sugar and insulin levels and more easily take appropriate doses.

Centralised framing: MEDs research agenda was centrally controlled and coordinated by the team leader and star scientist Paul. While MED's research focus on Type-2 diabetes emerged from a collaborative mission lab process, in the team's formal "kick-off" meeting in 2016, Paul presented a detailed workplan that he designed which mapped the team's research agenda over a nine-year period. This workplan became a guiding framework for MED and helped to monitor progress throughout Phase 1 funding. It divided MED's research agenda across three decentralised and clearly defined work streams. The three work streams were 1) model-based decision support and advanced physiome modelling, 2) development/design of a device to undertake needle-free sensing of glucose and delivery of insulin (incorporating module 1), and 3) (of highest risk) nanotechnology-based advanced point of care (i.e., real time) insulin sensors. In all, twenty projected milestones were specified and mapped across the research agenda's three work streams, culminating in a final year-nine milestone of an integrated and commercialised system in use. Observations and interview data provided ample evidence that Paul was MED's definitive leader and centrally coordinated the research agenda in a top-down way. For example, it was observed and noted how Paul would authoritatively chair team meetings and discussions, probing team members on their progress, and lead MED presentations, communication and project updates, and documentation. In some project documentation, a chart of the team structure was included with himself positioned at the top as leader and others positioned below him. Referring to his own sense of responsibility for MED's research agenda, Paul commented in an early interview "If this doesn't work out, my head is first on the block". When asked about key challenges for MED, Paul responded (albeit tongue in cheek) "There's only one of me". Furthermore, comments from interviews with team members emphasised that Paul was closely coordinating the various modules, how it was difficult to challenge his view in team meetings and that ultimately, they felt they had limited influence over the "direction" of the research agenda.

Stage 2: In 2019, Phase 2 funding for MED was approved. While the formal workplan submitted by MED as part of the Phase 2 funding application detailed progress across all modules, there were two notable research objective additions. The first objective was a light-based continuous glucose monitor (CGM), a serendipitous idea that arose from separate cardiovascular monitoring research. It was claimed the CGM would be a major step forward in glucose measurement for accuracy, adherence and ease. The second objective was the development of a low-cost insulin delivery pump. The 2021 SQI review concluded that overall, MED was progressing well and could make a significant impact.

Centralised reframing: The addition of the two new technical objectives that changed the composition and direction of MED's research agenda were driven by team leader Paul. Within the 2019 revised workplan, Paul explained that the new project components would "overtake" and "provide alternatives" to existing work streams, and "extend the breadth" of the original research agenda. It was stated:

> "New projects aim to overtake or provide alternatives to the areas with the highest technical risks in the NFSD (i.e., needle free sensing and delivery) platform, sensing in particular. They may also provide further services or disruptive approaches. These new projects run in parallel and extend the breadth of the overall programme of research without losing clinical focus."

The reframing of MED's research agenda embodied Paul's centralised control of the team's research process and his own flexible working style. For instance, in terms of how the new research projects came to be identified and incorporated within the modified research agenda, Paul referred to himself as an "opportunist" who did not feel constrained or overly committed to the composition of the original agenda. Comments from another member of the MED team provided further evidence of Paul's lateral thinking and flexibility when stating:

> "I've worked with him (Paul) quite closely for a while, and he's always got – well, he's always got a way of thinking about – well, that may not be exactly what we said we're going to do, but still it would be useful."

Further illustrating Paul's flexible approach, regarding the light-based CGM specifically, a member of the team recalled how Paul was "pushing" him to incorporate research developments he had made in a separate area within MED's research agenda, which the team member was "reluctant" to do as he felt it was premature - "Paul was pushing it, I think from more the NZTI side. He was like, this might be quite useful for the NZTI side of things, so have a go". Similarly, for the idea of the low-cost insulin pump, as illustrated in the interaction below, Paul explained how he quickly adapted, or did his "thing", after he was approached by a clinical champion for help to reduce the costs of insulin pumps.

> Facilitator: The low-cost insulin pump; how did this come –
> Paul: He walked into my office. He said, oh people in the hospital say you're the guy to see. An insulin pump costs $8000–$10,000.
> Facilitator: So (you) start thinking more about these types of things, rather than staying fixated on your slides (initial workplan) on day one, right?
> Paul: Yeah. I tweak them – I do my thing.

Table 3
MED's centralised framing of research agenda.

Team	Research Agenda (RA)	Stage 1 Early one to three years	Stage 2 Mid three to five years	Stage 3 Latter post five years
MED	Focus of RA	Develop needle-free sensing and insulin delivery device for Type-2 diabetes	Successful in phase 2 funding. Incorporates two new research objective additions 1) a light-based continuous glucose monitor (CGM) and 2) a low-cost insulin delivery pump.	Work on original objectives to continue post funding. Spinoff EWIP funded to advance transformed RA that is now wholly focused on Type 1 diabetes treatment through development of LED-based CGM and low-cost insulin pump.
	Centralised framing of research agenda	RA set out and tightly controlled and coordinated by authoritative (self-identified and respected) team leader within detailed workplan (4 modules, 3 workstreams, 20 milestones, over 9 years).	Leader's flexible approach and lateral thinking avails of opportunities – i.e., science developments for CGM and social ties for insulin pump – that help to address or provide alternatives to modules of highest technical risk in original RA. Dismisses other opportunities, i.e., external offers of assistance, to maintain tight control of RA.	Team leader designs and spins off EWIP and (largely) new team to focus on transformed RA. Offers continued support for novelty and feasibility of modules in original RA, whilst simultaneously establishing distance between their focus and direction and the new technical objectives within the transformed RA.
	Illustrative data	"I think part of it is, the structure of having a large project organised across multiple investigators is such that…I think there's not much scope for us in our role for changing the direction of the spearhead." "I think, to maintain the focus of the collaboration and make sure we're all trying to solve the same problem, it's much more helpful to centralise that (RA) discussion." "He (Paul) (is) keeping all the modules alive and keeping these modules working on their own thing." "I haven't worked as closely with Paul but what I saw in the last meeting we had that the other (team) folks attended was, I think, Paul is someone who doesn't take kindly to having his view challenged."	"I'm an opportunist at best, right? The pump thing came up; I was like, oh f**k we could do that…So, if you look at that, that's an even easier delivery than if it's not needle-free; it's one needle in, just like a patch pump. I've got funded scholarship (for) PhDs, two of them to work on this." (Paul) "I'm somewhat reluctant, I guess I'm slightly different to Paul. Paul will want to go out and do human trials and stuff straight away (for light-based CGM), and I'm trying to reign that in a little bit, because we want to get the technology, we want to make sure it works properly, and I'm pretty sure it will, but we've just sort of worked our way through the tests that we need to do, and so that's why we haven't sort of pushed it out too much further." "Paul is the nexus for big picture project planning on this project."	"Facilitator: What about XXX and XXX and XXX; do you just leave them continue or… Paul: I keep in touch with each of them, and I let them do their thing. All these things will come to hopefully the best fruition. I can't do a whole lot to jump the pace of what they do. The stuff with XXX; we've got different ideas, and they're being finalised to finish within the year. I think we'll see a thing; it'll be good science – it'll be high-risk stuff – I think it will need another five years to really come to anything else." (on the insulin sensor) – "There's a lot of other people that will want what he does for bio-security sensors and what have you, and they seem to be more exciting to him at the moment." (Paul) (on the jet-system insulin delivery) – "It'll work. It'll deliver, and we'll know exactly how much, we'll have an idea, anyway. I think it will be suitable for a Type 2 diabetes. I wonder if people would rather have that or a patch pump. That will be interesting. A patch pump, which is just another infusion set line, so it's cheaper is probably a safer and a better deal." (Paul)

Thus, Paul's flexible approach enabled and drove efficient reframing of MED's research agenda. Paul's centralised control of MED's research agenda was further evident in how he dismissed offers of assistance and support from outside the team. For example, in response to an offer of action research assistance to help the team engage with end users, Paul commented "For me, I'll be arrogant about it, there's not a whole lot he could do for me because I already know my end users at the clinics". In another instance, Paul firmly declined an (emailed) offer from the NZTI programme office to connect MED with an engineer who was deemed to have vast experience in MedTech commercialisation. Responding to the offer, Paul pointed out he had more spinouts that the contact person in question and that their list of work was "not focused", before closing his email reply with "IMO we have the expertise".

Stage 3: MED funding began to conclude in 2022, however, an EWIP building on MED's research received $995,000 in funding. The EWIP would focus on further developing the non-invasive CGM that used LED lights to detect blood glucose levels. The EWIP would also focus on developing the low-cost insulin pump that could deliver variable doses as required, thus distinct from the jet-system insulin delivery device detailed within MED's original research agenda. The pump would provide constant subtle ministrations of insulin, based on continuous readings from the non-invasive CGM, removing over and under dosing errors and the burden of these calculations from patients. Ultimately, the device would lower the cost of Type 1 diabetes treatment and help ensure patients automatically receive the right insulin dose at the right time.

Centralised transformation: As the only established member of the MED team formally listed on the newly funded EWIP, Paul would lead the transformed research agenda. Commenting on the potential impact of the EWIP, Paul stated "This is an artificial pancreas solution that's disruptive to existing markets. These technologies are world-leading in cost, power consumption and capability and would make New Zealand a leader in diabetes care". Other members of the EWIP team, that was spun-off and rebranded (i.e., no longer MED), primarily included (now) graduated PhD students and clinical stakeholders that had contributed to MED's earlier research activities. While interviews with original MED team members indicated they would continue to work on their respective science objectives once MED had concluded, it was apparent at this point that Paul was establishing some distance between the modules within the original research agenda and the transformed research agenda within the EWIP. For example, Paul explained that he kept "in touch" with team members responsible for some of the original modules. He reiterated that these areas of focus still had significant scientific merit and potential, but they would likely take some time (up to five years) to materialise. He also pointed out that, for some modules, he had different ideas to the people with responsibility for the module, but he was not interfering (i.e., "I can't do a whole lot"). Regarding specifically the workstream focused on developing a sensor to measure insulin in real time, Paul suggested that the work was starting to get attention from areas outside of MED (i.e., biosecurity), and that this might be of greater interest or "more exciting" to those team members leading this technical objective. Similarly, regarding the original workstream focused on the jet-system insulin delivery device, Paul appeared to support the feasibility and scientific novelty of this work, particularly for Type 2 diabetics, while simultaneously rationalising the idea that (i.e., "I wonder if…") a patch pump device availing of continuous measurement would

Table 4
MMA's decentralised framing of research agenda.

Team	Research Agenda (RA)	Stage 1 Early one to three years	Stage 2 Mid three to five years	Stage 3 Latter post five years
MMA	Focus of RA	Additive manufacturing: use of natural biopolymers and fibres to create novel 3D printing materials; develop suitable printer equipment; explore application to 4D printing.	Successful in phase 2 funding. Structured across three aims, RA focus shifts to applying biomaterials to 4D printing – products change shape, property and functionality in response to external stimuli - and exploring application possibilities.	EWIP funded to specifically focus on 4D materials and electromagnetism - develop reconfigurable antennas for the communication technologies industry.
	Decentralised framing of research agenda	Shared open leadership facilitate deliberations and bottom-up consensus-oriented development of RA within the team (i.e., between members and leadership and between designers and scientists) and outside the team (i.e., decentralised industry workshops).	Modified RA shaped through team wide deliberation and input. Leadership roles further distributed across new RA structure. Decentralised and collaborative approach to discussing (i.e., within and outside the team) and seeking consensus on RA development continues.	Team comprised of several leaders and collaborative science groups. EWIP with transformed and more focused RA formed collaboratively within team and spun out. New RA led by early career researcher and supported by several original team members.
	Illustrative data	"It's actually a very flat structure and there's very little definition between levels…when you see us at meetings, that is what happens; most of the direction is done on a very level playing field in terms of leadership." "They (leadership) accept opinions and new ideas anytime. In terms of scientific decisions of what's going to be made, it's quite horizontal. They just analyse and say, okay or we'll make you explain a little bit more, it's not vertical. They do not make only them the decisions. They are just helping organise it." "(It's) great to hear scientists saying, we want this to be design-led, but from our perspective in design, we see it as science-led technology and design-led applications. it's a two-way thing. Really inspired by the science, we can make the connections to the end-user, to the people, to the applications, but we can also go back to the scientist and put the demands on the science, and say, if you can tweak it like this it might even be more applicable. So, it's not just that we pick up the science and run with it." "If I look at today you had 50 people in one room discussing 4D printing. Industry - different industries, different organisations, universities, CRIs only talking about 3D and 4D printing with bio-diverse materials. It's a capacity that has never existed in NZ before. It has never happened…that in itself is a massive step in the right direction.""	"We looked at thinking, well let's try co-leadership. We had put both Philip and Helen together (with me) in leadership for the program. What's happened of course since then (for) Phase 2, we've set up co-leadership of different sub-programs within it too (and) projects within them." "The group is quite accepting of other directions and that has only grown, (is) slowly growing over the three years, to actually say, well we understand a bit more how you work, how you think, what you may end up doing." "They (prototypes) provide a solid basis where somebody could look at it for a few seconds and say, well why is (it) like that?… internally within the project, these things have been absolutely essential. I don't think we would have got as far as we did without that, if it had just been a series of slide presentations and talks. It does make it more real. It demonstrates physical properties, I think everyone was also very comfortable after a short time in bringing stuff that didn't work. You bring your failures as well as your successes." "We're now at a point where we collectively have a wide range of physical things, information, data that we can put in front of industry. So, it's not just asking industry people what would you be interested in as a manufacturer. We're giving them something to bounce off, to say; hey, this is what we can do, this is what we've got, this is what we think we can do, what are the opportunities you see?"	"When we know that (a) decision is being made, everyone had their input in it – everyone had a chance to pitch in, and if you haven't, that's the person's fault. I think we created a platform where everyone has the tools to say something (and) do something." "In terms of scientific development, I think it's more related to the individual group leaders. There are several group leaders inside the project. The research development or ideas (are) made within these individual groups." "We have different groups which people sort of champion. It's not to say that those groups are irrelevant to all the other groups; it's a very cohesive, collaborative environment. So, if somebody has something to say on a certain research aim, they say it, but we do definitely have distributed responsibility within the team."

be "cheaper, safer and a better deal". Further illustrating this point, the following comment shows how Paul on the one hand offered support and an update on the progress being made with the original jet-system insulin delivery, whilst questioning if this approach was too clumsy, thereby simultaneously legitimising the new idea of an insulin pump within the transformed research agenda he had spun off and was now prioritising.

> "So, the needle-free injection is close to commercialisation. We're still not sure, because we had to start trials again, on exactly how much insulin gets in, but probably most of it seems to be the number. So, it's getting close. I think it's too big and clumsy for what we want to do. Hence, the low-cost insulin pumps idea has come up"

4.2. MMA's decentralised framing of research agenda

Stage 1: MMA's research agenda focused on the use of natural (plant and animal based) biopolymers and fibres (e.g., lignin, cellulose, protein, keratin) to create novel engineered materials suitable for application in 3D printing. MMA's research also explored application to 4D printing (an area that was very early-stage science in 2016), which allowed what was produced to adapt and respond to external stimuli, such as temperature, humidity, moisture, light, pressure or electrical fields, among others. MMA's research would stimulate NZ's circular bioeconomy, working with companies on smart manufacturing techniques.

Decentralised framing: While the focus of MMA's research agenda was reasonably clear, in comparison to MED, its overarching design and direction was not defined. As explained early on by one team member, further exploration would be required to clarify the direction and potential market applications of their research.

"Ideally you would get your academic knowledge and direction you're going with the research, actually having a really good direct application, and there was absolute synergy between those two straight away. But often that doesn't happen, and because we are more blue sky looking at the future of where things are going, that direct application doesn't necessarily mesh straight away. Those gears don't match straight away".

Also, in contrast to MED, MMA did not have a single or authoritative team leader. Instead, MMA's leadership was shared among three colleagues, Sarah, Philip and Helen. As explained by a research informant, these leaders brought contrasting but complementary perspectives and expertise to the team.

"Sarah is at the centre of this whole activity, and she has been the driving force. She's also quite an industrial oriented person and brings all that orientation and personality through her presence in meetings and interactions. On more regular basis for contact and leadership we have Philip and Helen. That's a good arrangement (as) we have one from the academic background and the other one from the research institute (applied) background. So, leading (with) different philosophies or background expertise."

Alongside this shared leadership structure, informants commented that the team operated with a "flat structure" and on a "very level playing field". Illustrating this point is the following comment from a team member who was unsure who MMA's team leader(s) was/were.

"I don't even know who our leader is. Sarah is in charge of something to do with it. I always think of Sarah as in charge, because I would never dare argue with Sarah. Helen is obviously in charge, as well, somehow. I haven't really thought of it as an exact hierarchy of people. There are people with different responsibilities. I think that the way Philip behaves, I suspect that he's accountable for things. He quite often tries to bring the topics back to what's absolutely needed for the reporting and so forth".

Consistent with the aforementioned flat structure, early development of MMA's research agenda was decentralised and relied on wide input across the team. As explained in the following comment from a team informant, decision making on the direction of the science was inclusive, incorporating bottom-up contributions, rather than centrally dictated.

"The science decisions (are) being built by the whole team. Everyone has a chance to have input and to do something, and then (if) we go off-track, the management will step in and bring back everyone to contribute towards (the agenda), but I feel every single person in that group has a chance to contribute to the science."

Further evidence on the decentralised and collaborative development of MMA's research agenda was the purposeful incorporation of a design-led approach within the team. More precisely, by engaging both scientists and professional designers, early advancement on the direction of MMA's research agenda was informed by ongoing discussions on how science inspired novel materials could open up new options for, and be aligned with, design-led applications. It was stated:

"Connecting designers with early-stage research ensures human focussed design thinking is part of the earliest stage of the research. For the scientists, this guides the research toward real world potential applications. And for designers, who are used to being limited by materials which have attributes that are constant, they can see the potential of materials that are not static (and) can change. This affects how they conceptualise their designs."

MMA's decentralised deliberations were not confined within the team. Early in the research process, MMA's (shared) leadership initiated dedicated industry engagement workshops for the full team to participate in. Here, representatives from a wide range of industries and communities (e.g., Māori) were invited to interact with the MMA team. The purpose of these interactions was for MMA to discuss and get early feedback and ideas from external stakeholders on the direction of their science, and to begin the process of identifying appropriate industry partners with whom they could develop commercial relationships with over time. The following comments from two team informants provide some detail on this early decentralised external engagement.

"We've done it not in a, well let's figure out something you can use with our stuff and we'll do something with you. We've chosen to do it as a, here's a space for you to forget about your business, to just go free-minded as industry-players, and as Māori, what you might want to do. That's the nature of our industry day…So, it's an engagement. It's not a, make something for you. It's an interaction."

"I see the industry day as the start of what should be an ongoing process towards generating commercial relationships and then being able to connect IP to industry...unless we're really lucky and you get somebody there who says, hey – that's exactly what I want. I suspect that it's going to take a few industry days just to find the right people to have the right sort of level discussion, and to generate the amount of trust required, to make people realise the stability of this. A lot of what we're dealing with is fairly transformational things. So, it's a big risk."

Stage 2: In 2019, MMA successfully secured Phase 2 funding. The modified research agenda focused on applying biomaterials to 4D printing and was restructured across three distinct research aims with various projects within these.

Decentralised reframing: The team's decentralised approach to developing their research agenda appeared to be working effectively. As detailed by one informant, team-wide deliberation and input were fundamental to shaping the various components and direction of the modified research agenda for phase ("tranche") 2.

"There's respectful, strong debate on the science discussion; agreement where it's going, what's next? So, the design of Tranche 2 was done as a group, and the shaping of it, and what happened to the science in it, and where it went to."

With the new research agenda structured across three research aims/programs, co-leaders were assigned to each of these, thus further devolving formal leadership responsibilities within the group. As commented by a team member:

"Everyone leads to a degree, but as a bunch of leaders who are working together, the first round was Philip and Helen (and Sarah), and now we've got research aim leaders, so they've devolved leadership… so I think that basically everyone has one research aim that they are involved in leading."

While the structure of MMA's research had become more formalised across the various aims, the team's collaborative and consensus-oriented approach to advancing their research agenda remained prominent. For instance, in terms of decision making, one informant explained how science decisions within the group continued to be based on a consensus-oriented approach, just as they had been right from the outset of the research process.

"Decisions seem to come from consensus and collaboration, which I like. Everyone has an opinion…(a) perfect example of this; our project title has been discussed at length with the team. Everyone put forward their opinions and their thoughts and their ideas regarding it. We discussed it like a team, and we got to a point where we had somewhat a consensus."

In terms of deliberations, MMA started to produce several 4D "demonstration prototypes" that prompted valuable interactions within the team. For instance, MMA created a 4D printed tree that stood up when triggered by heat or water and an adaptive wrist split that could help with healing and rehabilitation. Team members were comfortable receiving critical feedback from each other – "you bring your failures as well as your successes". The team also shared prototypes at industry workshops to generate new ideas and discuss application possibilities across a wide range of industries – "what are the opportunities you see?". For instance, a 2021 industry workshop organised by MMA identified, among other areas, medical applications (e.g., customised wheelchairs, prosthetics), logistics (e.g., packaging designed for drone delivery), shelters (e.g., housing, sunshades, self-healing bricks), and sport (e.g., footwear, helmets, injury recovery) as application possibilities. In essence, as MMA's research agenda developed, the team continued to prioritise an interactive approach among each other and with industry, maximising opportunities to receive input and questions that could inform their science. As one informant commented:

> "They (industry) might be interested in where it (prototype) comes from, the unique process by which you can make a new material. They might be most interested in how you do 3D-printing, or they might be most interested in the 4D aspect – that is, what function does it have? We just don't know, so we've got to be prepared to be able to stimulate, engage - well, we want them to see something that will give the widest chance of different kinds of questions being asked."

Secondary data provided evidence that supported these findings related to MMA's deliberative and collegial approach. Specifically, in an updated formal workplan, MMA stated their group had "grown to become a fully functioning multidisciplinary collaborative team who can debate ideas openly and stay collegial". Moreover, the collegial and collaborative nature of the group was also commended in the formal 2021 external SQI review. Notably however, the 2021 SQI review also emphasised that, while MMA had many opportunities to deliver economic, environmental and social impact, a more focused approach would be required to advance technical development and application of the biomaterials. It stated:

> "There are many potential spin-offs yet to be pursued, however, without a specific application of focus, direct line of sight to beneficial impact is unclear".

Stage 3: In 2022, with the broader MMA programme set to conclude, an EWIP that had "grown out of" MMA's original research agenda was successfully funded for NZD350,000 over 12 months. Notably, the EWIP did not focus on biomaterials. Instead, building on MMA's general focus on 4D, it centred on magnetic fields and a specific use case, namely developing reconfigurable antennas that could "change their own shape, direction and surface to receive and transmit anywhere, all the time". It was argued that such sophisticated antennas would be important to pave the way for 6G wireless communication and beyond.

Decentralised transformation: MMA remained a highly collaborative team until the latter stages of their funding. For instance, it was re-emphasised that the group had created a decentralised "platform" where everyone had the opportunity to contribute or "pitch in" to science decisions. It was also explained by a team informant how effective collaboration among the cross-disciplinary and -institutional team members within MMA had resulted in new ties and research opportunities emerging organically through the team's work together.

> "Because our (project) takes a very collaborative research approach where there's multiple people from multiple institutions working on any project at any given time; because of that, new networks need new potential opportunities for collaboration that can be or have been identified. That's the beauty of multi-disciplinary collaboration; there's avenues which you don't think of exploring, and somebody makes it apparent to you…you're opening up a lot of opportunities."

Within this collegial team environment, and in line with the increased structure and devolved responsibility put in place for Phase 2, in the latter stages of the research process, MMA's research agenda contained (and had developed) several "group leaders" and "champions" with primary responsibility for science within their respective groups. In essence, MMA's research agenda had several collaborative research projects and "distributed responsibility" across these. Consistent with this structure and approach, in needing to address the critical feedback from the external SQI Review panel that suggested the line of sight to impactful application from the research remained too broad, MMA team members collaborated to design the successfully funded 4D reconfigurable antennas project. More precisely, supported by four members of the original MMA team among others, an early career researcher within MMA led the (team formulated) research agenda that was spun out within the newly funded EWIP.

4.3. *Team dynamics during framing of research agenda*

In the next section of our findings, we address the second (follow-on) question of our study: what happens within the science team during the framing of the research agenda? Specifically, we explored how the approaches and experiences of team members within each team evolved. Our findings detail several ways in which team developments stabilised and surfaced tensions within MED and MMA's research agenda development paths. We provide summaries and illustrative data of the findings in Tables 5 and 6.

4.3.1. *MED*

Team stability: Paul's unambiguous framing of the research agenda, through its explicit focus and direction, provided team members with significant levels of clarity. Through this clarity, team members had considerable freedom to focus on their own science tasks. As stated by one team informant early in the research process "at this point in the project…we are here really as a group on our own trying to solve the issues that we know that we need to solve in order to contribute to the bigger project". Within the centrally framed research agenda, team members regularly commented that the decentralisation of explicit technical objectives meant there was little (vertical) interference or micro-management from Paul as leader. Distinct projects and objectives within the broader agenda also meant there was little horizontal interaction within MED. More precisely, clear parameters around the decentralised research projects meant there was limited expectation of, or need for, cross-module collaboration among the "quasi-independent" sets of activity. The findings provide evidence that team members welcomed their high levels of autonomy and freedom to focus directly on their own science objectives. Further supporting this point, several team members explained that they were "not at all motivated" by activities related to commercialising the NZTI-funded research, Instead, as illustrated in the following comment from a team informant, they were primarily driven by the science objectives within the research agenda, and the "public good" that could come from focusing on those science activities.

> "It's clear that there will be the potential for commercial outcomes from this work….it is on the radar but I wouldn't say it's my target. It's not what's driving me to work on this project. I'm not driven to do this project in order to create a commercial outcome. I believe that there will be commercial outcomes that will flow from it but I'm more motivated by the community outcome, if you like, the public good outcome of doing this science."

Notably, while there was limited interaction between the various

Table 5
Team stability/spillover within MED's centralised framing of research agenda.

Team stability	Research agenda direction and support from leader	"I would say our component, so XXX and myself, I think XXX and XXX's work is really a very separate piece. We don't actually talk to them as part of the project, and that, I am not concerned about, because frankly, there's very little technical discussion to be had between us. There is not really a lot of communication on an everyday basis because we don't need that…the parameters are fairly well defined for us." "There's no operational relationship between the parts that we do and it's not necessary; there's nothing about what we're doing that would help them do their research better – there's nothing about their research that would help us do ours better." "He's (Paul) been very generous. Our team have been generously supported from the grant, probably compared to the others, to keep people like XXX and XXX engaged on the project, and that's been very much appreciated. If there is any sort of adverse effect on our interaction, it certainly hasn't made material difference, or it hasn't had a deleterious affect on our ability as a team here to contribute."
	Team autonomy to focus on own science	"Part of the way that we're able to work together without killing each other is that it's a very, beyond the fact that Paul is the touchpoint for big picture decision-making, we don't actually talk to him a whole lot. So, he's the leader, but not the day-to-day manager. So, it's leadership without micro-management". "The way the project's been structured…the different pieces of the project are pretty well decoupled from each other. So, it's not as though there's really day-to-day hierarchy in the project that needs to be respected and followed." "It doesn't make much sense to invest a lot of time (on collaboration) because we're all solving our technical challenges. We all come to the project to bring our different skills, in a project like this, that breaks up into several pieces in a very straightforward manner, (it is) designed to break into several pieces that could be quasi-independent." "I'm a little nervous about the whole entrepreneurial side and commercialisation side as to how well it will be received by everyone in the Challenge… (some) of us are not entirely motivated, perhaps not even at all motivated, by commercial outcomes and continuously having that pushed upon us might create a bit of pushback."
	Opportunity to learn from leader	"I think for a project like this, it doesn't make sense to spread out stakeholder engagement across all of the different groups… because if that happens, what that inevitably leads to is a number of separate research groups working on separate projects that are vaguely related to a common theme". "I think our expectation in the NSC is that Paul is serving as the point of contact for external stakeholders." "He's (Paul) a visionary. He has the vision. He always has the vision. So, he can see the big picture; what's the market, what's the impact on the health system and everything." "He (Paul) stresses maybe the economic side of things (with research) maybe more than I do. I would have said he possibly has the more equally balanced – maybe that's just because he's more experienced at it than I am." "The commercial side is important (but) the driving goal is the science, the healthcare challenges. You absolutely want to be making sure you're thinking about the commercial side…So you have to have the commercial outcomes but that's never the goal in itself." (Paul) "There is industry there that's very interested in the potential outcomes through (company name) and potentially other companies but there's a number of problems to solve before they would start investing money in it." (Paul)
Team spillover	From autonomy to siloes	"I would characterise it by saying that we're keeping our heads down, and tackling the tough things that we already have to tackle, that we know are important. My understanding is we actually still have a fair amount of time on the clock." "It's actually kind of nice just to get on with life, and to get on with business, knowing that you're all still working towards the same (science) goal." "I would say for us, we have stayed focussed on the original goal. We have had other research projects start up, other ideas in the injection we've looked at, but we have not made significant changes to the technical approach we're applying. Sure, the very low-level details of the actual research and the precise method we thought might work at the end of the project has been tweaked and worded in a slightly different way, but that's very low-level details." "There's got to come a point, and it's coming up soon, where we need to be talking a lot more, but we're still feeing our way into this, as I see it." "Paul has been, I would say, very good at shielding – it's probably the right word – shielding us from a lot of the administrative aspects of the XXX project, and that means that we don't have necessarily as much knowledge of what's going on." "Before we used to have twice a year meetings…at least we knew what they are doing and what are we doing, and what direction should we go, but this year it was like there was no meeting, and nothing going." "Maybe it is entirely possible that, it is just my perception, the sort of cooling, the coincidence of timing, that maybe it's just that we all got bogged down in the details of achieving our technical objectives, and as a result, the level of collaboration naturally moved, because I think that piece of collaboration is what's missing."
	Technical bypass from efficient reframing	"It's all great; they've got a lead on something (i.e., CGM technical objective) – they want to chase it, but in doing so, they're pursuing a parallel path to what we're doing. There's no place in the integrated device for both technologies".

(*continued on next page*)

Table 5 (*continued*)

	"I think we've perceived over the past year and a half or so – certainly something I felt the last group meeting that we did have was that they became very enamoured of their optical method of glucose-sensing – because they were looking at that non-invasive infrared method – that is actually something that renders us irrelevant." "When I was going through their webpage and I saw the light sensor for glucose…I was actually down in XXX in January to see XXX and Paul, because I was the examiner for one of the PhD students…I was talking to them and they didn't mention anything. I think it wasn't developed at that stage. Something happened after that, and then now I went to the website; oh, really."

work groups and the leadership regarding MED's centrally framed research agenda, team members did point out that they were "generously" resourced through Paul's leadership, and this allowed them to focus on their respective work streams. The findings also provide evidence that team members had a unique opportunity to learn from Paul's leadership. For instance, it was apparent throughout the research process that Paul centralised control of the team's external engagement activities, namely engaging with industry partners and other interested stakeholders such as clinicians and patient users, and that team members welcomed this centralised approach and regarded it as appropriate. Illustrating this point is the following comment from a team informant.

> "For us to go out and say 'hey Paul, we've had a chat with the patient group, and they actually think we should totally change how we're doing this' – would not be – that wouldn't be kosher. I would not feel comfortable doing that, and it's nothing to do with Paul. I think in any sort of large-scale focussed project, it's important for changes – for externally-motivated changes to be something that gets managed in a more centralised way".

Further evidence of the learning opportunity for MED team members was their unanimous acknowledgement that Paul was a "visionary" leader who had the experience and expertise to simultaneously lead the science, and to think strategically about its impact and potential commercial application. For instance, in an early team presentation, it was noted how Paul emphasised to the group the importance of MED keeping track of "milestones and progress to ensure we remain relevant and have not been superseded by new technologies, ideas, ways of doing business or systems". Moreover, in interviews and discussions with Paul at various stages of the research process, he explained how he was inclined to factor in potential industry interests and commercialisation pathways, whilst prioritising science objectives. As illustrated in the following exchange, those who worked with him were expected to, over time, develop a similar mindset on this issue.

> Paul: There are a lot of researchers that have no market or impact context whatsoever.
> Facilitator: Less-so at this school, I'd imagine with the…
> Paul: I would say less-so if you're within my radius.

Team spillover: As MED's centrally framed research agenda developed and changed over time, so too did dynamics within the team. The data provides evidence that team members continued to have high degrees of autonomy and they used this to focus on their respective technical objectives, confident that these remained relevant to the broader research agenda and did not require significant adaptation. However, the data also provides evidence that, several team members began to talk differently about their autonomy. Seemingly growing in confidence and frustration during the research process, team members started to explain that they would welcome more contact and interactions with Paul and other groups within MED, and also, greater understanding of and involvement in how the centrally framed research agenda was progressing. The following comment from a team informant speaks to this point.

> "I can see how what Paul's doing and what we are doing can eventually come together, although I need to get more up to date with where Paul and the team currently are…so, I don't know what their latest activities are, and he probably doesn't know ours, apart from what we've submitted in reports. So, there's that whole issue. As far as where XXX and others and that side of it fit in, I'm not entirely sure how the modelling that they are doing or have done – I don't know if they're still doing it – is (it) going to integrate into this whole workflow – that's a little more nebulous to me. In terms of what XXX is doing with his people to develop an insulin assay; again, that was a longer-term part of this so, I can see more easily how our work and Paul's work can come together. That's dependent on, I think, how well we can automate the process of extracting blood".

However, team members' interest in having more horizontal and vertical collaboration did not materialise. Instead, the limited engagement that did take place, for instance through formally scheduled team meetings, began to wane and the team became more fragmented. Some team members began to wonder if they had become too focused – "bogged down" - on their own science objectives and that this had impaired team collaboration. Then, and as outlined in the first section of our findings, what transpired was MED's research agenda was centrally transformed and a new variation of the team's research programme was spun out by Paul. The centralised and efficient manner by which this occurred and became apparent to other MED team members is illustrated in how various team members, first noticed and remarked on the formulation of "alternative" technical objectives, then explained how threatening this was for their involvement within the research agenda, and finally, after finding out more through their own research efforts, outlined their surprise at the significant impact the new developments would have on the team's original research agenda. Overall, the manner by which team members' autonomy gradually became siloes, and how they eventually experienced technical bypass through the efficient reframing of the centralised research agenda, surfaced some tensions within MED, however, these tensions are interpreted (see discussion) as a scenario of team spillover. It is important to note that, despite these tensions, MED team members continued to work on their original research objectives and the merit of these continued to be supported by Paul. While Paul had spun off a new team, other members of MED had started to build their own collaborations external to the team – "we are not collaborating that much with other people in the project, but mostly with the people outside of the project". Moreover, as illustrated in the two comments below, by the end of the research process, team members appeared to more fully appreciate the novelty of Paul's transformed research agenda, and how it had evolved from the original agenda which they had contributed to. The centralised manner by which the new research agenda was reframed was also better understood.

> "We put the needle-free injection as the main component of this project, but if we managed, as part of this collaboration, to build a new sensor that makes even needle-free injection irrelevant, that's fantastic….I know their team (subgroup) was developing the light sensor for blood flow or pressure….but if the sensor can get glucose, that would be amazing because we can get continuous measurements…this is very novel…This is very significant."

Table 6
Team stability/spillover within MMA's decentralised framing of research agenda.

Team stability	Team accountability for/ownership of research agenda	"(An) advantage of this group is that people are not shy to put forward ideas. There doesn't seem to be a lot of people who are shy because they're worried about some kind of internal hierarchy."
		"As we progressed, based on the work that we were doing, and based on the areas we were representing, many people (were) identified as leaders, and that was based around the amount of input we were putting in. I became a leader in Phase 2 where I'm actually contributing a lot. So, my work was recognised, and (I) was given a role there to lead a component of the research along with two others who are also experts in the same field."
		"It's that kind of just stepping up and doing, which I think is largely because people actually believe in this group, people believe that what we are trying to achieve is going to work, and that this is really worth doing."
		"(The structure) gives accountability and engagement, it kind of forces us to talk to each other regularly and…I want to be there; having this co-leading part, (it) allows people to be accountable, because if nothing is being done in that respect, (it) means that we haven't done our jobs. So, I think there's a really good aspect (to) doing that."
	Autonomy to collaborate across team	"This really speaks for the leadership within the team…(they) have allowed us to operate as a team where you are open to say, I don't really know – how is this relevant? isn't this what it should be? Having an environment (with) that discussion develops capability…to ask those questions and talk through trying to resolve."
		"There's had to be a lot of leadership within this, with lots of people taking – by leadership in this case, I mean people taking a problem as their own (and) trying to find a solution…you know what I mean; it's people who basically just said, oh this is a problem – I'll do something about it. I do see a lot of that."
		"Industry gives us a feedback and directions and also they critique. They're critiquing (whether) what we're thinking is making sense or not, in terms of the product which comes in 10–20 years."
		"It's good that we profile our science and technology with industry, get early input so that the outputs of our research are fit for purpose rather than academic"
		"It's much more like a family in that you can get a bit irritated with your brother at times because he's arguing all the time, but you know it's a good robust discussion, and nobody bears a grudge or anything like that. Occasionally there's slight manipulations. Philip was a bit of a ratbag last time; he was slightly manipulative…it was interesting. It was a little interruption temporarily, but because we've got enough trust, we were able to move past it…It was just a bit of an eye-opener again, reminding us that we are all working on slightly different trajectories."
	Opportunity to learn as leader	"What can't be under-valued is (the) good mentorship, those who have led before, identifying potential in those who can be leaders, and facilitating training. In my team, (we've) all been leaders in some way, shape or form for years now. I know personally I've had a lot of awesome mentorship."
		"I've had a lot of opportunities, and I'm incredibly grateful to my team for those opportunities to stand up, to discuss to some degree, have sort of leadership-like responsibilities to develop my capability.
Team spillover	Inefficient formulation and development of research agenda	"(A) consequence that I see for this leadership (is) there needs to be a little bit more active management, ensuring that contributions from others are drawn out, but also done timely in conversations rather than having someone jumping in and speaking and going off on a tangent."
		"To try and develop those relationships, and making it collaborative for the rest of it, I think it's taken quite a while to happen, not because people didn't want it to happen, but because people had to find what were the areas that they could work together or what were the skill sets that actually made a difference."
		"I think it has taken probably a year and a half to start to actually understand how we can work together…to get outputs which actually start to blend skills and opportunities within the group."
		"Scientists (are) using different language in our part compared to the designer. We and they also use different language compared to somebody who's doing mathematical modelling of structures. They use different language from engineers who are developing systems for doing this stuff. Actually, there's a huge communication barrier. It was interesting in the first few meetings, you got people talking and not quite following what anybody else was saying, and they'd be sometimes talking about the same thing but using vastly different language and (coming from) different directions."
	Research agenda path dependence	"It's (biomaterials) in the title of our project, so we are somewhat limited to do that. It does present some unique challenges, just keeping to biomaterials. That can help with research, that you're in a new research space (but) if you're keeping to that restriction of just bio-materials, which I am, it creates challenges"
		"The consensus at the last workshop was that if we are getting future funding in spin-off projects, that we won't put restriction on it all being bio-based; we won't reject bio-based materials, but we'll be more open to other materials and hybrid materials Then, those projects will be a bit more application-focussed…so, we will definitely consider bio-based materials an option, but the goal will be the product concept rather than the materials going into it."

"They (Paul's group) have IP protection around all the stuff that they're doing. So, they may not be willing to talk about the idea, they want to protect that as part of their – I mean we are part of the same group, but – yeah, these are innovative ideas and that's protecting the IP."

4.3.2. *MMA*

Team stability: Members of the MMA team also had considerable levels of autonomy throughout the research process. However, in contrast to MED, the autonomy within MMA arose through a lack of structure, both in terms of hierarchical leadership authority and research agenda design. Regarding leadership, the data provides evidence that alongside the shared leadership structure, leadership authority within MMA was weakly enacted and there was no evidence of explicit leadership control of the team's research agenda. This arrangement appeared to be positively received within the team. More precisely, it was found that, from the outset, team members sought out and embraced responsibility for co-developing the team's research agenda. For instance, team members were quick to "step up" and "put forward ideas" and over time, increasingly believed in and took ownership of the research agenda. Moreover, as the research agenda was developed, team members were proud to be identified and selected as formal leaders based on their science contributions, embraced their increased "accountability", and began to view development of the team research agenda as their core role - "our job". Regarding research agenda design, the data provides evidence that throughout the research process, MMA members welcomed and valued the freedom they had to collaborate, critique and contribute to cross-boundary interactions and science decision making within the team. That is, they were not constrained by specific objectives or parameters of activity within the research agenda, but instead regularly took the initiative to act and offer assistance when they felt it was necessary. Finally, and undoubtedly emanating from the above, towards the latter end of the research process, several team members commented on the beneficial career learning and development opportunities within MMA. More precisely, reflecting on their experience, team informants explained how they had benefitted from mentorship, training and other opportunities to contribute and assume formal leadership roles within the team.

Team spillover: For the most part, the emphasis on team collaboration and devolved leadership responsibilities supported MMA's decentralised framing of their research agenda.

However, a corollary of this approach was that framing and reframing of the research agenda was not always as efficient as it might otherwise be. It was noted by several team members that, from the outset, the leadership within MMA's was quite light touch – "Philip and Helen are relatively gentle leaders, as in we are gently reigned. We're like horses that don't know we're being guided. You know?". As illustrated in the following comment from an informant, this leadership approach, which appeared to be more akin to project management than leadership, persisted within MMA as their research agenda developed.

> "It's very team leadership and there's not really, I mean, it's not even really leading the research aim, it is to a degree, but it's also more guiding rather than leading; making sure everyone is on track, and that things happen when they're supposed to happen."

This hands-off leadership appeared to contribute, at least in part, to some unproductive team discussions. For instance, it was reported by some team informants that the coordination of team meetings could have been more effective to ensure all perspectives were heard and also, to ensure that science discussions didn't lose focus. In essence, the emphasis on team-wide collaboration and consensus within MMA, coupled with a leadership approach that was more faciliatory than decisive, meant early framing and clarification of the team's research agenda took some time. Absent centralised coordination, it was left to team members to themselves resolve the complexities within their multidisciplinary group, and to develop and agree on a research agenda that leveraged their various areas of expertise. Illustrating this point, a team informant commented "it's taken a long time to really work out what the science focus is, particularly with the design contribution – how do we fit into that? I'd say over the last year we've identified a number of projects." Along with influencing the formative years of the team's research agenda, the persistence of MMA's inclusive and collaborative approach had implications for how their research agenda was reframed over time. More precisely, a commitment to previous decisions that were made collaboratively created research agenda lock-ins that constrained its adaptability. Specifically, team informants explained how it took considerable time and effort for the group to reach consensus on loosening their original (agreed) focus on biomaterials. Although remaining uneasy about loosening this focus, when the decision to change was made, it allowed new science directions and opportunities to be considered, such as that of reconfigurable antennas which was subsequently funded through the EWIP. Thus, overall, while MMA's collaborative and consensus-oriented approach supported the decentralised framing of the research agenda in many ways, the lack of leadership authority and control within the group also contributed to some inefficiencies and inflexibilities in this area. Again, these findings are interpreted (and will be discussed) as a scenario of team spillover.

5. Discussion and conclusion

The purpose of our research was to explore how research agendas are framed in science teams. Our findings reveal both top-down (Snow et al., 1986) and interactive (Gray et al., 2015; Reinecke and Ansari, 2021) framing are applicable to the collective action frame (Benford and Snow, 2000) of research agendas within science teams. We also identified team dynamics related to learning during research agenda framing: team stability and team spillover. Table 7 provides a summary of these findings and below that we discuss the theoretical contributions and practical implications of our research through several propositions related to: leadership influence on research agenda framing; the reframing of research agendas; team organisation and learning facilitated by research agenda framing; and how research agenda framing can impact spillover.

5.1. Implications for theory and practice

First, our research contributes new knowledge on how research agendas are framed. Specifically, by adding new insights on the influence of science team leadership on research agenda framing, our research adds to existing literature which highlights how research agendas can be heavily influenced by star scientist leaders (Tzabbar, 2009; Tzabbar and Vestal, 2015), and how research agenda implementation and development is influenced by discipline-based social and cognitive configuration alignment (Shinn, 1982) and collaborative dynamics including team composition (Porac et al., 2004). We do so by detailing two distinct approaches to framing research agendas. Through centralised framing, research agendas are embodied and dictated by a visionary science team leader. This approach shows how centralised design and control by the leader results in limited research agenda discussion within the team and limited opportunities for members to influence the (re)direction of the research agenda. In contrast, through decentralised framing, multiple team members discuss and deliberate the composition and direction of the research agenda. In this approach, science team leadership is weakly enacted and leadership responsibilities are devolved over time as the research agenda is co-developed by members of the team. Taken together, we show that framing of the research agenda is influenced by the degree to which science team leaders centralise and pass down or decentralise for deliberation the organisation of research agendas. Based on this discussion, we develop the following proposition:

P1. Centralised framing of a research agenda is tightly controlled by a visionary science team leader. Decentralised framing of a research agenda involves team wide engagement and deliberation on the research agenda.

Second, our research contributes to theory on framing processes, specifically how the prevalence of framing contests can slow decision making (Kaplan, 2008) and the implications this can have for the dynamism and transformation of frames over time (Cornelissen and Werner, 2014; Gray et al., 2015). More precisely, our findings show how the lack of framing contests in MED's centralised framing of the research agenda, coupled with Paul's flexible working style, enabled efficient reframing. Eventually, frame transformation and science renewal

Table 7
Summary of findings.

	Centralised research agenda framing	Decentralised research agenda framing
Leadership	Singular	Shared
Team structure	Hierarchical	Flat
Design and coordination of RA	Top-down and modular	Co-developed bottom-up
Internal and external team deliberations	Narrow	Wide
Team decision making	By dictate – decisive	By consensus - contested
RA transformation mechanism	Leader-controlled spin-off with (largely) new team – separation and exit	Collaboratively formed spin-off with (largely) existing team – grow from within
Potential benefits	Flexible reframing	Joint formulation/selection of science
Potential risks	Reliant on one 'best' way	Less flexible reframing
Implications for science team learning - Team stability (supported when)	Team members have limited strategic responsibility for the research agenda with high levels of science guidance and secure resourcing provided; high levels of autonomy and freedom to focus on their own science tasks; and the opportunity to observe and learn from an experienced leader as they centrally drive the research agenda.	Team members have high levels of responsibility and accountability for research agenda through its co-development; high levels of autonomy and freedom to collaborate and deliberate on science issues across the team (i.e., loose RA parameters); and the opportunity to learn as leader by stepping into leadership roles and availing of mentoring and training.
- Team spillover (enabled when)	Team members grow uneasy with siloed autonomy and seek both greater horizontal collaboration within the team, and greater (vertical) engagement in and responsibility for development of the research agenda. Team members recognise how decentralised science objectives are displaced by the centralised transformation of the research agenda.	Team members see the value of strong and decisive leadership to coordinate science deliberations (e.g., more efficiently distil opportunities and set science directions) and accelerate decision making in the absence of consensus (e.g., identify and address unproductive lock-ins within research agenda).

occurred through leader-controlled separation and research agenda spin-off with a new team. In contrast, the contested and consensus-oriented decision making in MMA's decentralised framing of the research agenda contributed to both the initial framing and reframing being less efficient. In this team, frame transformation and science renewal eventually occurred through a collaborative team-driven spin-off involving several members of the original team, led by an emerging researcher. These findings lead to the development of the following proposition:

P2. Reframing and transforming a research agenda is more efficient when control of the research agenda is centralised by a visionary science team leader than it is when control of the research agenda is decentralised and contested among the team.

Third, our research contributes to literature on learning and the development of scientific and technical (S&T) human capital within science teams. According to Bozeman and Corley (2004), S&T human capital is the skills, knowledge and relationships required to engage in science. Our findings add to this literature by showing two distinct S&T human capital learning environments within science teams that are related to how research agendas are framed. More precisely, our findings suggest that centralised framing of the research agenda in MED was stable and supported when the leader's control was accompanied by a team environment in which members were comfortable with: high levels of science guidance and resourcing, but limited strategic responsibility for the team research agenda; high levels of autonomy and freedom to focus on their own science tasks; and the opportunity to observe and learn from the experienced leader as they drove the teams' research agenda and external engagement activities. In contrast, we found the decentralised framing of the research agenda in MMA was stable and supported when accompanied by a team environment in which members were content with: high levels of responsibility and accountability for the team's research agenda through its co-development; high levels of autonomy to collaborate across the team and to make decisions through deliberation and consensus; and opportunities to learn as leaders by stepping into formal leadership roles and the provision of formal mentoring and training. Thus, our findings explicate that S&T human capital learning in MED was more passive and experience based, while in MMA it was more active through direct involvement and responsibility. In connecting approaches to framing research agendas with modes of team learning, we provide new insights on the organisation of work within science teams (Haeussler and Sauermann, 2020; Shinn, 1982; Walsh and Lee, 2015). Our findings also provide more nuanced insights on team learning in the context of research agenda development over time. More precisely, prior research suggests that learning in teams can be curtailed by the presence of high-status team members as they may limit team wide input and involvement (Bunderson and Reagans, 2011; Van der Vegt et al., 2010). Our findings show that early, as opposed to later, in the research agenda development process, this arrangement may be welcomed by the team and appropriate to the framing of the research agenda. That is, our findings show that team members looking to advance their science careers may, at certain times, welcome the opportunity to have high levels of autonomy and limited responsibility, whilst working under the direction of a visionary science leader. Overall, based on these findings we develop the following two propositions:

P3. Centralised framing of research agendas facilitates passive team learning where team members have high levels of science guidance and resourcing, but limited research agenda responsibility; high levels of autonomy and freedom to focus on their own science tasks; and the opportunity to observe and work with a visionary leader.

P4. Decentralised framing of research agendas facilitates active team learning where team members have high levels of responsibility and accountability for the team's research agenda; high levels of autonomy to collaborate and deliberate across the team; and opportunities to learn as leaders through mentoring, training and stepping into formal leadership roles.

Fourth, our findings inform the development of propositions on science team spillover. Previous research highlights that the accumulation of experience and knowledge by inventors and scientists and their subsequent career mobility is consequential for science diffusion and spillovers (Agarwal et al., 2009; Slavova et al., 2016; Tzabbar, 2009). Our research adds new insights to this literature in the context of framing and reframing research agendas in science teams. Our case studies provide evidence that as both research agendas approached transformation and spin-off, some frustrations and tensions surfaced. Within MED, a discernible shift occurred as members grappled with their deeply rooted autonomy. They began to seek more team interactions and more responsibility and involvement in shaping the research agenda. However, these changes did not materialise, and their development within the team and individual science projects were displaced by the centralised transformation of the research agenda. We theorise that, if left unaddressed, such frustrations among science team members will result in spillover tensions. More precisely, a lack of involvement in research agenda framing coupled with sparse team collaboration and interactions risks engendering a scenario where team members experience hindered growth due to omission or over-dependence, and possibly exit science teams prematurely in frustration. Prior literature shows that star scientist- and leader-centralised control of team research agendas, while beneficial in many ways, can impair the contributions and development of other team members (Kehoe and Tzabbar, 2015; Tzabbar and Vestal, 2015), often because the team members don't see their own contribution as valuable or necessary (Li et al., 2020). Scholars have also suggested that the potential negative effects of such centralised leadership control can be mitigated (and the positive effects heightened) when the leader collaborates (i.e., greater mutual dependence) (Kehoe and Tzabbar, 2015) and interacts more frequently (Li et al., 2020) with team members. Our findings have relevance to these insights. We posit that enhanced engagement in the framing of the research agenda and more interaction between MED's central leader (Paul) and the team may have reduced the likelihood of, or better managed the, frustrations and tensions emerging within the team. This could further enrich team members' overall learning and experience, even if the reframed research agenda went in a different direction to their science focus. We believe this would help to ensure more productive spillover from science teams, such as the development and diffusion of future science leaders and the imprinting and dissemination of effective strategies for framing research agendas among the broader academic community. Specifically, we propose:

P5. When framing of research agendas is centralised, in order to enhance spillover, visionary leaders need to balance between the benefit of reframing efficiency and enabling greater interaction and development opportunities within the team.

However, our investigation into the MMA team also reveals that an overemphasis on collaboration and consensus-driven decision making can engender its own set of tensions. Despite the team cohesion and rich opportunities for leadership development within MMA, the findings show that team members became frustrated at times by the lack of friction or decisive leadership to coordinate team discussions and clarify the direction of the research agenda when consensus had not been reached. The absence of decisive leadership to counterbalance ongoing team deliberations in the framing and reframing of research agendas may compromise spillovers or reproduce inefficiencies and unproductive lock-ins in research agenda framing in future collaborations. Therefore, our final proposition states:

P6. When framing of research agendas is decentralised, in order to enhance spillover, team leaders need to balance between the benefits of collaboration and leader development opportunities, and path dependent decision making.

5.2. Limitations and future research

Our research is not without limitations and offers some potentially rich lines of inquiry for future researchers. Our research tracks two teams over seven years. While this timeframe and the in-depth case studies allowed for the identification of two approaches to framing research agendas, future researchers can extend our findings by examining this topic more closely. The propositions we have developed offer a foundation for this work. It would be particularly worthwhile investigating how centralised and decentralised framing of research agendas impact research agenda development across a more diverse (e.g., discipline areas, team size, leadership style, geographic dispersion) set of science teams. Within this, tracking data on team productivity and co-authorship trends during research agenda framing and reframing would also be valuable. Another important area for exploration is how framing processes impact team learning and the motivations and choices of individual scientists who self-select into or depart science teams. Related to this point, the role of prior ties among team members and how prior experiences and expectations might relate to how research agendas are managed and framed also holds rich promise. Our propositions related to spillover are also worthy of further study. Team environments in science imprint practices that are disseminated among future research collaborations and therefore, influence the future of knowledge production. Examining in closer detail how scientists' engagement with research agenda development contributes to productive as opposed to destructive spillover would be a valuable line of research to inform current and future science leaders. Overall, we believe our study on research agenda framing in science is novel, timely and significant. The lack of extant theory on this topic demanded an inductive grounded approach. We believe the insights provided here pave the way for exciting research that can further enrich our understanding of research agendas in science.

CRediT authorship contribution statement

Conor O'Kane: Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Vincent Mangematin:** Conceptualization, Formal analysis, Writing – review & editing. **Jing A. Zhang:** Conceptualization, Methodology, Writing – review & editing. **Jarrod Haar:** Methodology, Writing – review & editing.

Declaration of competing interest

We the authors declare that we have no conflict of interest in submitting this paper for review and consideration.

Data availability

The authors do not have permission to share data.

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