Fostering multidisciplinary collaboration in drug discovery

Drug discovery teams combine specialists with in-depth knowledge from a variety of scientific disciplines. Such diversity in thought worlds poses a challenging exercise in cross-disciplinary collaboration and project co-ordination. Based on a longitudinal field study of five projects in a leading pharmaceutical company, we present a framework outlining the conditions for effective cross-disciplinary collaboration in drug discovery teams. We show that knowledge creation in multidisciplinary teams relies on a combination of formal team structures and informal co-ordination practices. Formal team structures set the boundary conditions for cross-disciplinary co-ordination. Within these boundaries, self-managed sub-teams draw on informal co-ordination practices involving cross-disciplinary anticipation, synchronisation and triangulation, to overcome knowledge boundaries and high uncertainty. We identify five key insights and two questions which are important for managers to consider for fostering multidisciplinary collaboration in drug discovery.

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The challenges facing members of diverse teams are well known[1-3]. Multidisciplinary teams, in particular, include individuals with vastly diverging thought worlds, scientific practices, approaches to problem solving, communication patterns, timelines and technologies for knowledge creation. An additional source of complexity is that drug discovery teams are always in flux: as scientists push the knowledge frontiers in human biology, unpredictable findings and emerging obstacles require that the team composition is continuously modified. Turning such diversity into complementarity demands is an ongoing effort of team leaders and project members[4-6].

Effective team co-ordination across different disciplines is essential for successful drug discovery. Yet high task uncertainty and complexity involved in this process makes it very difficult to design an optimal formal team structure[7-9]. The changing nature of the scientific questions and unpredictability of its evolution challenges team co-ordination[10-13]. In a recent field study[20] we analysed how project members performing complex knowledge creation activities collaborate across knowledge domains and which organisational structures help successful teams defy knowledge boundaries and facilitate progress. To answer our research question, members of five drug discovery projects in a global pharmaceutical company were interviewed and observed during project team meetings, lab work and other day-to-day interactions for a period of more than 18 months in 2011 and 2012. The project teams included specialists from medicinal chemistry, structural biology, preclinical safety,

Table 1: Overview of drug-discovery project[20]

PROJECT TEAM	NOVELTY OF THE TARGET	STAGE IN DRUG DISCOVERY		THERAPEUTIC AREA	NO OF RESEARCH SITES
		STUDY START	STUDY END		
CanPro1	Medium	Lead identification	Lead optimisation	Oncology	1
CanPro2	Very high	Target identification	Target identification	Oncology	3
CanPro3	High	Target validation	Terminated (by end 2012)	Oncology	2
AutoPro	High	Lead identification	Lead optimisation	Autoimmune diseases	1
InflaPro	Very high	Assay development	Lead identification	Inflammatory diseases	1

translational medicine and project team leaders, among others (see **Table 1**).

Our data included 68 semi-structured interviews (lasting between 60-90 minutes) with scientists and senior managers directly involved in these drug discovery projects and non-participant observations of 55 instances of interactions of team members during project team meetings, sub-team meetings, during their bench work and informal discussions. We took extensive field notes on site after each observation. The final data consisted of field notes and the transcribed interviews, which in total consisted of 1,097 pages of single-spaced text. We analysed the data by doing an axial coding with NVivo 9 software[14].

Findings

Effective team co-ordination

The progress of drug discovery teams hinges on the ability of its members to answer emerging scientific questions regarding disease states, target activity and compound structures. The difficulty herein lies both in performing domain-specific scientific and technical work and combining competences from different knowledge domains[15,16]. Teams do not progress if either of these components is missing. Indeed, scientists can be hugely successful in creating exciting insights about lead compounds within the confines of their own domain. Yet without the continuous collaboration and alignment with other domains, such knowledge may be largely useless to the advancement of drug discovery.

While it may be clear that effective team dynamics rest on common goals, it is less obvious what specific solutions and behaviours should be encouraged in multidisciplinary teams to ensure that common goals are achieved. In our analysis of drug discovery teams, we discerned formal and informal co-ordination as two mutually reinforcing organisational mechanisms that enable specialists in multidisciplinary teams to create knowledge. Based on our analysis, we have identified five key insights for managers responsible for drug discovery:

Insight 1: Balance formal and informal co-ordination

Organisations divide overarching goals into subtasks, which are allocated to individuals. Because distributed tasks need to be integrated at some point, this division of labour creates interdependencies between different individuals responsible for these tasks. Co-ordination refers to efforts to manage such interdependencies.

As with any organisation, pharmaceutical companies have both formal and informal co-ordination mechanisms in place. Formal co-ordination is based on formal decisions and regulations about how the work within an organisation should be organised, whereas informal co-ordination cannot be predefined or imposed but emerges out of daily informal relations between individuals[17,18]. The most commonly-used formal and informal co-ordination mechanisms can be seen in **Table 2**.

A key formal co-ordination mechanism in drug discovery project teams concerns the assignment of individual specialists to sub-teams responsible for specific scientific questions. Such formal co-ordination falls under the authority of project team leaders and involves an assessment of which knowledge domains are relevant (and interdependent) for answering a scientific question at any point in time.

Within these formally created sub-teams, individuals also bring to bear informal co-ordination practices to manage the team's internal interdependencies[19]. We refer to these as informal practices

References

1 Argote, L, Turner, ME, Fichman, M. To centralize or not to centralize: The effects of uncertainty and threat on group structure and performance. Organ Behav Hum Decis Process 1989;43:58-74. doi:10.1016/0749-5978(89)90058-7.

2 Cardinal, LB, Turner, SF, Fern, MJ, Burton, RM. Organizing for Product Development Across Technological Environments: Performance Trade-offs and Priorities. Organ Sci 2011;22:1000-25. doi:10.1287/orsc.1100.0577.

3 Gardner, HK, Gino, F, Staats, BR. Dynamically integrating knowledge in teams: Transforming resources into performance. Acad Manag J 2012;55:998-1022.

4 Burns, Tom; Stalker, GM. The management of innovation. London: Tavistock Publications; 1961.

5 Sherman, JD, Keller, RT. Suboptimal Assessment of Interunit Task Interdependence: Modes of Integration and Information Processing for Coordination Performance. Organ Sci 2011;22:245-61. doi:10.1287/orsc.1090.0506.

6 Argote, L. Input Uncertainty and Organizational Coordination in Hospital Emergency Units Author(s): Linda Argote Source : Administrative Science Quarterly, Vol. 27 , No. 3 (Sep., 1982), pp. 420-434 Published by: Sage Publications, Inc on behalf of the Adm Sci Q 1982;27:420-34.

7 Cardinal, LB. Technological Innovation in the Pharmaceutical Industry: The Use of Organizational Control in Managing Research and Development. Organ Sci 2001;12:19-36. doi:10.1287/orsc.12.1.19.10119.

8 Jelinek CBS, Mariann. The Innovation Marathon: Lessons from High Technology Firms. Oxford: Blackwell; 1990.

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because they do not derive from formal rules or procedures, but are learned on the job and honed through experience. One important finding of our study is that formal and informal co-ordination mechanisms are not substitutes but complement each other. Therefore managers should find a balance between them by providing initial structures around project teams and then allowing the teams to self-organise team restructuring around emerging interdependencies and the interactions between the scientists. The following three insights are related to the three informal co-ordination practices that we observed to be necessary for effective team work and the last one is related to how sub-team outsiders play a role in reconfiguring formal structures.

Insight 2: Anticipate cross-disciplinary requirements

Interdisciplinary collaboration in drug discovery requires specialists to be constantly aware of the implications of their domain-specific knowledge creation activities for other specialists. To prevent cross-domain inconsistencies, team members should have a forward-looking approach in which specialists anticipate the procedures, requirements and expectations of the other domain. This means that the domain specific activities should primarily be valuable to answering the scientific question and progressing in the discovery of a new drug, rather than just yielding interesting insights for the scientists own domain.

Experienced drug developers understand that this may require that they compromise domain-specific standards of excellence for the common good. Indeed, applying best practices within a domain may cause challenges across domains. For example, a computational chemist designing a novel compound in a way that is difficult to synthesise is unlikely to benefit the team's progress.

Insight 3: Pay attention to synchronisation of workflows

Disciplines have their idiosyncratic priorities and ways of pacing and ordering activities. Thus when working in multidisciplinary teams, specialists need to openly discuss and be aware of temporal interdependencies and plan resources in a way that cross-disciplinary inputs and outputs are synchronised. For example, for testing a particular compound, a pharmacologist may need several weeks to grow a tumour model in mice. Unless the medicinal chemists have the compound ready in time, the mice might not survive and the experiment would incur a delay.

Insight 4: Triangulate assumptions and findings across disciplines

Given the demands on compounds' safety and efficacy profiles, drug discovery specialists need to establish the reliability of the knowledge they create not only within, but also across, knowledge domains. Practices supporting this objective include aligning experimental conditions and parameters as well as triangulating research findings. For example, *in vivo* data generated by an immunologist in animal models and *in vitro* data from a biochemist's independent enzyme assay result from different experimental set-ups that should inform each other.

At each point in the process, scientists should scrutinise the findings and assumptions in their own work by going back and forth across disciplines to ensure that their output constitutes useful input for others. Such efforts involve sensitivity to misunderstandings that may arise from domain specific terminology and criteria.

Insight 5: Get the opinion of team outsiders

In our research, we found that regular project level interactions between sub-team insiders and sub-

FORMAL CO-ORDINATION MECHANISMS	INFORMAL CO-ORDINATION MECHANISMS
Organisational structure: grouping of organisational units	Lateral or cross departmental relations
Centralisation or decentralisation of decision making through formal authority	Informal communications
Formalisation and standardisation: written policies, rules, job descriptions, standard procedures	Socialisation: Building organisational culture of sharing strategic objectives and values
Planning: Budgeting, functional plans, scheduling, etc	

Table 2: Examples of co-ordination mechanisms[21]

team outsiders was a powerful driver of progress. Contributions from outsiders challenge sub-team members to rethink their thought processes and counters the perils of sticking to familiar approaches. In many cases we observed, suggestions and even seemingly naïve questions by outsiders about the sub-team's assumptions helped to foreground unexplored questions or open up new areas of discussion, and may eventually lead to spark sub-team restructuring, onboard specialists and resolve deadlocks.

To illustrate, in one case we observed, a sub-team was working on a rat model to investigate the metabolic profile of a compound. During a project team meeting, an *in vivo* biologist discusses her experimental design. A pre-clinical safety specialist attending the project team meeting observes potential differences between rats and mice and their respective similarity to humans. After the discussion, the sub-team decides to onboard the safety specialist to investigate the different reactions in rats and mice.

Recommendations for leaders

Formal organisational structures are often considered constraints to innovation. Contrary to this view, our study shows that formal structures have an important role in guiding the informal co-ordination practices that lie at the basis of knowledge creation. Leaders and managers of drug discovery projects should ensure they provide the right balance of formal and informal structures to ensure an environment that is congenial to cross-disciplinary collaboration. To understand how such a balance can be achieved, it is useful to consider the varying responsibilities and activities of project team members forming the core of a particular sub-team, and those members at the team's periphery.

Yet because knowledge creation is a dynamic process and interdependencies between specialists can only be foreseen to a limited extent, team structures also need to remain flexible and allow for individuals across the organisation to participate and collaborate spontaneously. For this to work, enabling informal co-ordination practices and interactions with sub-team outsiders are critical.

Project sub-team members, outsiders and team leaders should share the responsibility of initiating changes to the team composition and onboarding sub-team outsiders when progress falters. Changes in formal team structures require sub-team members to acknowledge the permeability of team boundaries, identify the need for outside knowledge, be open to external opportunities and have the confidence to reach out to other specialists. Allowing project teams to formally restructure sub-teams also requires a supportive project team environment. Pharmaceutical companies run multiple projects in parallel, each branching out in a number of sub-teams. Such an environment presents a competition for specialists. Against this background, project team leaders should encourage teams to flexibly change their composition over time, and ensure an environment in which there are sufficient slack resources to enable this flexibility.

In conclusion, the flexible organisation of project teams adapting to changing scientific questions and balancing formal and informal co-ordination is a powerful driver of progress in complex drug discovery projects. In the pharmaceutical industry where speed to the market is an important competitive advantage, managers should think about how to recognise the need for restructuring in a fast manner and allow firms to effectively co-ordinate their efforts. We believe that enabling agile drug discovery teams is extremely important for speeding up the innovation process. In this manner, the following questions are highly relevant and timely for managers to consider:

1) How can drug discovery teams become more agile? Which approaches (eg Scrum, Design thinking, Kanban, etc) could be used to improve co-ordination of drug discovery work?

2) How can digital technologies foster agility in knowledge co-ordination activities? DDW

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9 Child, J, McGrath, RG. Organizations Unfettered: Organizational Form in an Information-Intensive Economy. Acad Manag J 2011;44:1135-48.
10 Ancona, DG, Caldwell, DF. Bridging the Boundary: External Activity and Performance in Organizational Teams Author(s): Deborah G. Ancona and David F. Caldwell. Published by Sage Publications, Inc. on behalf of the Johnson Graduate School of Management, Cornell University. Adm Sci Q 1992;37:634-65.
11 Cronin, MA, Weingart, LR. Representational gaps, information processing and conflict in functionally diverse teams. Acad Manag Rev 2007;48:1107-23.
12 Dougherty, D. Interpretive Barriers to Successful Product Innovation in Large Firms. Organ Sci 1992;3:179-202. doi:10.1097/CCO.0b013e3280 1173fb.
13 Faraj, S, Sproull, L. Coordinating Expertise in Software Development Teams. Manage Sci 2000;46:1554-68. doi:10.1287/mnsc.46.12.1554.1 2072.
14 Strauss, AL CJM. Basics of qualitative research: Techniques and procedures for developing grounded theory. Thousand Oaks, CA: Sage Publications; 1998.
15 Grandori, A, Soda, G. A relational approach to organization design. Ind Innov 2006;13:151-72. doi:10.1080/ 13662710600684316.
16 Hülsheger, UR, Anderson, N, Salgado, JF. Team-Level Predictors of Innovation at Work: A Comprehensive Meta-Analysis Spanning Three Decades of Research. J Appl Psychol 2009;94:1128-45. doi:10.1037/a0015978.
17 Okhuysen, GA, Bechky, BA. Coordination in organizations: An integrative perspective. Acad Manag Ann 2009; 3:463-502.

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18 Von Krogh, G, Nonaka, K, Rechsteiner, L. Leadership in organizational knowledge creation: A review and framework. J Manag Stud 2012;49:240-77.
19 McEvily, B, Soda, G, Tortoriello, M. More Formally: Rediscovering the Missing Link between Formal Organization and Informal Social Structure. Acad Manag Ann 2014;8:299-345. doi:10.1080/19416520.2014.885252.
20 Ben-Menahem, SM, Von Krogh, G, Erden, Z, Schneider, A. Coordinating knowledge creation in multidisciplinary teams: Evidence from early-stage drug discovery. Academy of Management Journal. 2016 Aug;59(4):1308-38.
21 Martinez, JI, Jarillo, JC. The evolution of research on coordination mechanisms in multinational corporations. Journal of international business studies. 1989 Sep 1;20(3):489-514.

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