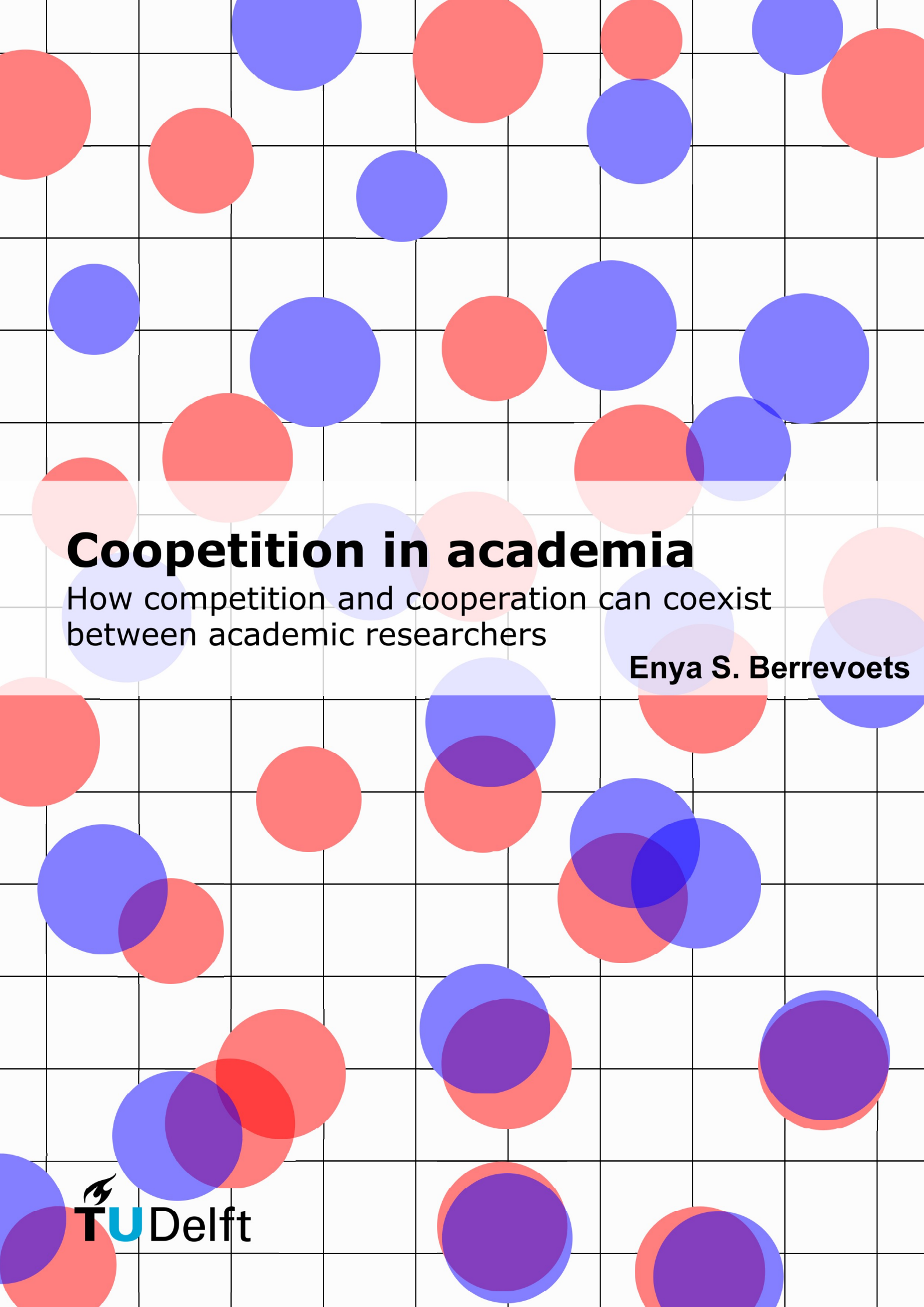

Coopetition in academia

How competition and cooperation can coexist between academic researchers

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TU Delft

Coopetition in academia: how competition and cooperation can coexist between academic researchers

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to obtain the degree of Master of Science
at the Delft University of Technology,
to be defended publicly on July 3rd, 2022

Student number:	4592778	
Project duration:	October 10, 2022 – July 3, 2023	
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This thesis is confidential and cannot be made public until December 31, 2023.

TU Delft

Contents

1. Introduction

Among the most integral values in academia is the understanding that scientific findings "are a product of social collaboration and are assigned to the community" (Merton, 1973). This understanding is demonstrated by the priority system, a reward structure that encourages the dissemination rather than the monetisation of knowledge. In the priority system, researchers share novel discoveries to lay their claim to them. Once shared, these discoveries are public goods that can be freely used by anyone; in return, the researchers' reputation is improved by their established priority of the discoveries, leading to new job opportunities, access to funding, and other (financial) rewards (Stephan, 2012).

A limitation to this incentive system is that it mainly rewards significant or positive results. As a consequence, non-significant or negative results are less commonly shared, a phenomenon referred to as the publication bias (Dickersin, 1990). This issue is addressed by the Open Science movement, which gained traction in the 2010's (Mirowski, 2018). Among other things, like the removal of pay walls in front of scientific papers, the Open Science movement aims to increase the publication of negative results, as well as that of the supporting experimental and observational data. In their extensive 2012 report on Open Science, The British Royal Society recommend the revision of scientific publication policies and the introduction of reward structures aimed at all scientific sharing (Boulton et al., 2012) This advice was adhered to through various national and international initiatives, such as the Dutch "Recognition and Rewards" initiative aimed at rewarding a broader range of academic qualities and achievements (Dutch Research Council, 2019).

However, while these measures encourage knowledge sharing through additional extrinsic motivation, relating to external rewards (Ryan, 2014), they do not address an existing dilemma researchers face: publishing their discoveries and techniques can boost their reputation, but doing so comes at the risk of others taking the information and using it for their own academic credit or commercial success (Nelson, 2016). This concern is especially valid now that the academic climate is becoming increasingly competitive (Edwards and Roy, 2017). In the competition for financial and human resources and for academic esteem, researchers are found to be more reluctant to share the data behind their findings (Haeussler, 2011). The question then arises how researchers navigate the tension between the pursuit of common goals and the emerging competitive pressures.

A similar question has already been explored in the context of commercial organisations. Here, the combination of competitive and cooperative interactions between rival firms is denoted by the amalgamation "coopetition". The starting point of coopetition between commercial firms, or industry coopetition, is the inherent rivalry due to the competition for limited resources and customers. This relationship becomes coopetitive when the involved firms show selected cooperative behaviours, most commonly the exchange of expertise and the sharing of physical and financial resources (Corbo et al., 2022).

Such behaviours are often motivated by the desire to innovate. Innovation through knowledge development and application is recognised as a key source of competitive advantage, and thereby commercial success (Corbo et al., 2022). A lack of in-house capabilities or resources required for the pursuit of innovation, especially common in small and mid-size enterprises (SMEs), then motivates outsourcing through inter-organisational agreements (Feranita et al., 2017).

The joint innovation through the exchange of knowledge and resources makes industry coopetition reminiscent

of the modern academic environment. In the current study, the concept of coopetition is therefore extrapolated to academic relationships to answer the research question (RQ): **how and why do academic researchers combine competition and cooperation in their relationships with fellow researchers?**

Scientific research on academic cooperation, and how competitive forces affect it, is not new. Social scientists have long recognised the value of cooperation between researchers and the effects competition may have on it (e.g., Van Den Besselaar et al., 2012), while also questioning the intuitive idea that the research performance improves with increased cooperation (e.g., Abramo et al., 2009). The novelty of the current study therefore lies less in the topic at hand, and more in the angle from which this topic is approached: the congruence of academic competition and cooperation was studied using theories from the industry, in which, different than in academia, competition is considered to improve a company's performance while cooperation represses it (Li et al., 2018).

To perform this study, the research question was first divided into three sub-questions. To answer **sub-RQ1 "What existing coopetition theory is relevant to bottom-up academic coopetition?"**, the existing literature on industry coopetition was searched. The focus of this search was on the concepts and definitions used in coopetition research.

The findings then informed the theoretical framework around which a survey was composed. The aim of the survey was to answer **sub-RQ2 "What are academic researchers' experiences with professional competition and cooperation?"** Motivated by the high individual autonomy of academic researchers (Niemczyk and Rónay, 2022), the survey assessed these researchers' intrinsic motivations. Both in the survey and in its subsequent analysis, a bottom-up approach was employed to see how these motivations translate to interpersonal and interorganisational relationships. To examine a broad range of researchers without exceeding the scope of the study, the survey was directed only at professional academic researchers working in microscopy-related fields. This categorisation includes research foci from fundamental optics, to microscope engineering, to (biological) studies at and below the micro scale.

Following the survey, a design study was done to answer **sub-RQ3 "How can academic researchers be assisted in navigating the tensions within and between professional competition and cooperation?"** Motivated by the discrepancy, suggested by the survey data, between researchers' perceived and actual competitive sentiments, the Guide for Introspection on Competition and Cooperation (GICCo) was developed. This computer-based tool comprises an interactive interface in which users can indicate and adjust their levels of competition and cooperation and receive personalised information on these topics in response.

The current study serves as an exploration of the concept coopetition in the context of academic research. Points of interest were identified from the literature search and the survey, which can be used for more intensive follow-up and future explanatory studies. The increasing knowledge base can then be used to dynamically update GICCo, so as to provide both individual and groups of academic researchers with handles to manage their interpersonal and inter-institutional relationships in a environment that is becoming increasingly competitive.

2. Literature search methods

2.1 Literature search

To answer the main research question, "How and why do academic researchers combine competition and cooperation in their relationships with fellow researchers?", a thorough understanding was required of the concept of coopetition and the state-of-the art of research on it. Starting from the 2022 review of Corbo et al. on innovation-related coopetition (Corbo et al., 2022), a **snowballing literature review** was therefore performed to answer three questions, the first of which was dissected into another three sub-questions:

- How is coopetition defined in existing research?
  - How does coopetition relate to competition and cooperation?
  - What is the typology of coopetition?
  - What does coopetition look like in practice?
- What theoretical frameworks is existing coopetition research built on?
- Which coopetition-related theories are relevant to bottom-up academic coopetition?

The last of these questions can be recognised as a variation of sub-RQ1, which the literature search was designed to address.

The explicit mention of the term "coopetition" was not a strict inclusion criterion, as this term is not usually used outside specific commercial contexts, even when it does apply.

The novelty of the current study lies in the assessment of coopetition in the context academia rather than industry. Accordingly, the topic is approached from the perspective of the aspects in which the two fields are most different: the operating employees, rather than the executive level, and behaviour arising from the level of these employees, as opposed to top-down practices. In line with this, the literature search was mainly focused on research with the coopeting individual as the unit of analysis, and on bottom-up coopetition.

3. Theoretical framework

3.1 Defining coopetition

Coopetition as a two-dimensional concept

Research on competition and cooperation between commercial organisations has long been focused on either one of the two concepts separately (Bengtsson and Kock, 2000). This reflects the common perspective of managers to frame a relationship as being either competitive or cooperative (Figure 3.1, left). Coexistence of the two is then explained as a trade-off, where an increase in competitive behaviour means a decrease in cooperative behaviour and vice versa. The problem with this mentality is that competitive behaviour within an alliance is thought to corrupt the cooperation (Khanna et al., 1998). The concept of coopetition therefore emerged as an alternative to the one-dimensional view of business relationships. Instead of placing competition and cooperation at opposite ends of the same axis (e.g., Thompson and Sanders (1998)), they are described as two related yet "diametrically different logics of interaction" (Bengtsson and Kock, 2000)(Figure 3.1, right). Within the field of coopetition research, some still choose to stay close to the traditional view of competition and cooperation by describing coopetitive relationships as either competition-dominated, equal, or cooperation-dominated Quintana-García and Benavides-Velasco (2004), while others explore the two-dimensional space between the competition and the cooperation axis to study "the dynamic interplay between competitive and cooperative phenomena" (Lado et al., 1997).

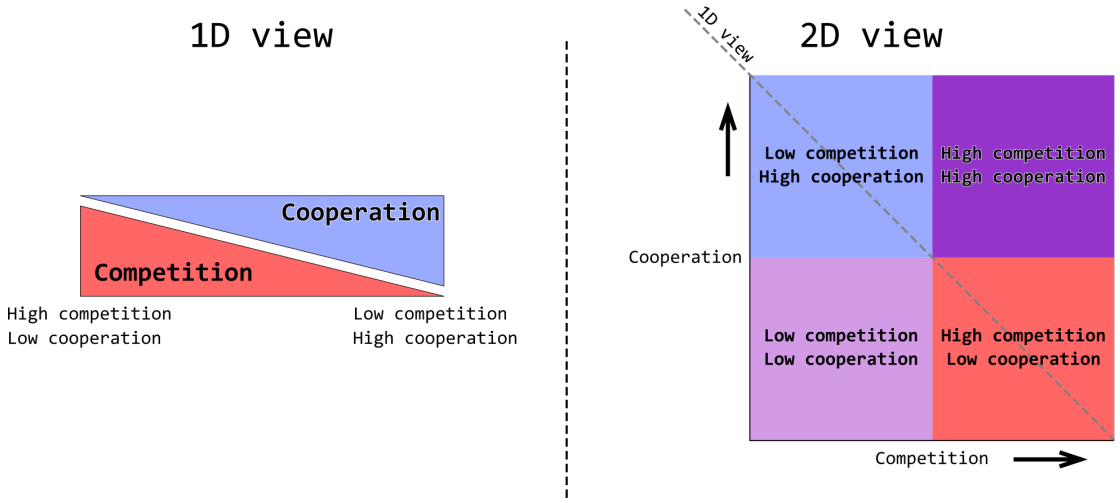

Figure 3.1: The 1D and the 2D view of competition and cooperation *(Left) The 1D view of competition and cooperation places the two concepts at opposite ends of the same spectrum. Coexistence of the two is then always a trade-off, where an increase in one means a decrease in the other. (Right) In the 2D view, competition and cooperation are separate (though not fully independent) variables, between which a 2D plane of interactions exists.*

Horizontal and vertical coopetition

Relationships between organisations can be either horizontal, when the organisations provide the same goods or services in the same industry, or vertical, when the organisations fulfil a different position in the

supply chain (Chai et al., 2020). Most existing research on industry coopetition is focused on horizontal relationships. An illustrative example, explored by Klein et al. (2020), is the relationship between different airlines. Providing the same service (flights), these companies are in direct competition for customers (passengers) as well as resources (pilots, aircraft innovations, furniture, etc.). Simultaneously, airlines often enter into cooperative agreements with rivals to offer shared flights, joint loyalty programmes, and common terminal lounges (Chiambaretto and Dumez, 2016; Klein et al., 2020). This is then an example of **horizontal coopetition**.

Because horizontal companies are in direct competition, cooperation between them comes at the risk of opportunism. Indeed, an ambiguous relationship was found between horizontal coopetition and product innovation, where mutual learning between rivals can have a positive effect on innovation, yet sharing knowledge can decrease this effect (Estrada et al., 2016) and inhibit revolutionary innovation (Bouncken and Kraus, 2013).

Contrary to horizontal coopetition, **vertical coopetition** is not based on direct competition for resources and customers, but arises "due to the multifaceted roles and relationships organisations can share with each other and with the present or future competitive tensions among sellers and buyers" (Bouncken et al., 2016). An example was the alliance between technology multinational Amazon and home appliance manufacturer GE Appliances: the two cooperated to add the control of home and kitchen appliances to Amazon's virtual assistant Alexa, but they simultaneously competed as Amazon sold their own microwave (Chai et al., 2020).

The research on vertical coopetition is limited, but it also shows ambiguity with respect to innovation. Of note, Chai et al. (2020) revealed a positive association between vertical coopetition and innovation aimed at producing products more efficiently (i.e., efficiency process innovation), but a decrease of this positive influence with increasing coopetitive interactions due to arising affective conflict. Regarding product innovation, (Bouncken et al., 2016) found that transactional vertical coopetition, in which formal contracts dictate the partners' rights and obligations, decreases product innovativeness (Bouncken et al., 2016), while alliances embedded in social relationships improve the innovativeness.

The work on both horizontal and vertical coopetition, and how they affect innovation, reveals the importance of interactions at the individual level. As stated by (Kale et al., 2000), such interactions can help cultivate mutual trust and curb opportunistic behaviour.

Bottom-up and top-down coopetition

In research, social and behavioural phenomena are often considered on three main levels of analysis: the micro level, relating to individuals, the meso level, relating to the social groups these individuals navigate, and the macro level, relating to the ecosystems in which these social groups exist (Figure 3.2). A holistic view on coopetition, one such phenomenon, require multilevel analyses, that account for the micro to macro (**bottom-up**) as well as the macro to micro (**top-down**) processes (Bengtsson and Kock, 2014). Researchers using the **top-down approach** investigate how coopetition is embedded in the higher, organisational levels and affects the lower, operational levels from there; the **bottom-up approach** is focused on the cognitions and emotions of individuals and how these affect interpersonal interactions and higher-level groups.

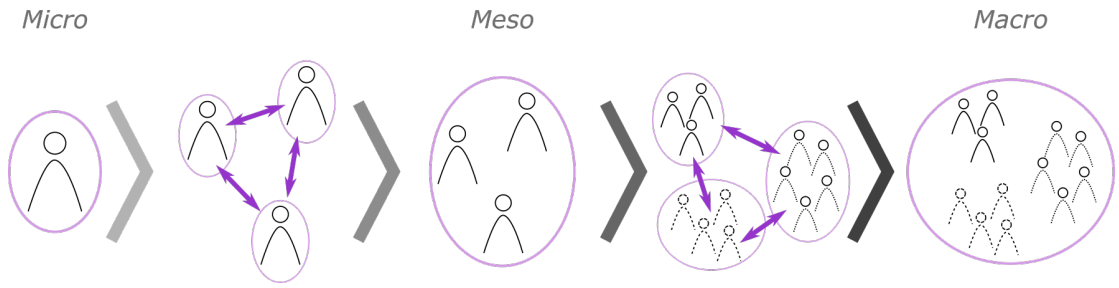

Figure 3.2: The three levels of analysis in social sciences. *Social and behavioural phenoma are typically studied on three levels of analysis, each with different units of analysis: the micro level relates to individuals, the meso level to groups of people, and the macro level to more abstract social systems and cultures. Interactions exist at every level and can often be placed on the fluid boundary between the levels.*

3.2 Multilevel theoretical framework

The distinction between the three levels of analysis was used to construct a theoretical framework. It is important to note, however, that competitive, cooperative, and coopetitive processes as well as the theories describing them are rarely isolated to one level. Economic theorems, for example, are typically linked to the executive and organisational level because executives have the formal job to consider the finances of their organisation, but this does not mean that operational employees do not care about their organisation's economic welfare whatsoever. Multi-level coopetition analysis therefore means to not only investigate coopetitive mechanisms at different levels, but to also study how these mechanisms influence and are influenced by each other and to understand that the boundaries between them are fluid, if at all existent.

Micro level analysis

Coopetition at the micro level concerns the cognition and behaviour of the individuals involved. Most importantly, it relates to who these individuals choose to share their professional knowledge, skills, and resources with and why. The individuals studied in micro-level coopetition research are typically those at the executive level, who have the authority to implement a coopetitive strategy (Corbo et al., 2022). Motivated by the benefits of coopetition to their organisation, they stimulate their operational employees to exchange knowledge or share resources with employees from competing organisations. Such benefits can be found from the **resource-based view**, which poses that competitive advantage stems from "owning unique, valuable, inimitable, non-substitutable capabilities" (Quintana-García and Benavides-Velasco, 2004): in a network with multiple competitors, choosing to cooperate with some of these competitors can broaden one's resources and thereby, according to the resource-based view, one's competitive advantage. This cooperation should, however, be recognised as coopetition and remain a calculated effort: to maintain a competitive edge, organisations must be careful with sharing their unique capabilities externally.

A nuance to the resource-based view is provided by the **dynamic capabilities approach**, which acts more at the meso than at the micro level. The proponents of this approach state that the accumulation of valuable assets is not sufficient to achieve a sustainable competitive advantage; organisations also require the capacity to exploit existing internal and external resources resources, both physical and tacit, to address their changing environment (Teece et al., 1997). A coopetitive strategy can be an indicator of such capacity, as it shows how organisations fluidly engage with one another to employ assets complementary to their own, as opposed to the more traditional approach of isolated acquisition of assets.

A limitation to the aforementioned theories is that they simplify humans to purely rational beings. Findings

from the field of **behavioural economics**, which is focused on the effects of psychological, cognitive, and social factors on behaviour, are then required to explain deviations from the behaviour predicted from such "rational theories". One commonly invoked concept is that of bounded rationality, introduced by Simon (1972), which rejects the idea that human decision making is a purely rational process to optimise the outcome. Building upon this concept, behavioural research on industry coopetition has revealed three conditions that affect coopetitive relationships (Corbo et al., 2022):

- It is difficult to anticipate courses of action when the same action can lead to different outcomes and, vice versa, an outcome can be caused by different actions;
- Cognitive bias drives people to misestimate their abilities;
- Evaluating outcomes is difficult when there is subjectivity in their indicators.

These conditions affect people's willingness to form coopetitive relationships, the coopetition process itself, and the way individuals value this process throughout and afterwards. Hence, it is advisable to always consider them in addition to any other theory used to explore micro-level coopetition.

Such considerations are especially valuable when exploring behaviour in academia, where one of the cornerstones to modern practice is individual autonomy: researchers should be mostly free to decide on their scholarly activities themselves, rather than having to follow a strategy imposed from the executive level (Niemczyk and Rónay, 2022). This autonomy is not absolute, as researchers do need to adhere to general university and government guidelines, but a coherent view on academic coopetition still requires attention to personal motivations, both for engaging in coopetitive relationships and for pursuing academic research in general.

Ryan (2014) developed the following framework for work motivation in research scientists, based on the five sources of work motivation identified by Leonard et al. (1999):

1. **Internal self-concept motivation** was found to be the strongest motivator. It stems from a desire to fulfil one's self-perceived potential and motivates work that is congruent with how individuals view themselves.
   Example: "I do this work because it challenges me to use my skills and talents."
2. **Goal internalisation motivation** was prevalent among the studied researchers as well. This motivator arises when an individual's personal goals and values align with those of the organisation they work for.
   Example: "I work for this company because I agree with their missions and goals."
3. **Intrinsic process motivation** was equally common and is derived from a sense of enjoyment and intrinsic reward from the work itself.
   Example: "I do this work because I think it's fun."
4. **External self-concept motivation** was especially prevalent among younger researchers. It relates to the validation of an individual's traits and abilities by others, such as their co-workers or employers.
   Example: "I work harder when I know others are evaluating my work." (Ryan, 2011)
5. **Instrumental motivation** was the weakest motivator. This motivation stems from tangible rewards and outcomes, such as salary and promotions.
   Example: "I do this work because the salary is high."

While this framework can also be applied to scientific endeavours in general, reasons to engage in academic coopetitive behaviour specifically can be found from the literature on academic knowledge sharing. Academia is build on the concept of knowledge sharing, but only a fraction of the scientific knowledge is distributed formally through publications (Song et al., 2010). Sharing additional information,

such as negative results and raw data, is then a cooperative practice driven largely by personal motivations rather than professional requirements.

Knowledge management is an important focus within the **knowledge-based view**, an extension to the resource-based view in which knowledge is recognised as a resource of particular value (Grant, 2002). Increasing attention is given to the tension between knowledge protection and joint innovation in networks with formal and informal, competitive and cooperative relationships. In the context of academia, Berthoin Antal and Richebé (2009) characterise knowledge sharing as a gift exchange that can be explored using **gift exchange theory** (also known as **social exchange theory**). This theory pertains to cooperative gestures that are motivated by the expected returns, but in which both the timing and the nature of these returns are indefinite. While the authors' explorative study provided more anecdotal than statistically significant evidence, their findings were in line with the theoretical expectations, thus indicating the applicability of GET in the context of academic knowledge exchange. One relevant notion is then that, according to GET, the exchange should be informal and non-contractual. As such, it should ideally be motivated from the bottom up. It can also be incentivised by managers and policy makers, but should not be explicitly rewarded, to avoid disingenuous sharing or the suspicion thereof. Paradoxically, however, gift exchange theory also dictates the importance of the countergift: tension typically grows when knowledge sharing is not reciprocated. Exploring this paradox, Berthoin Antal and Richebé found that although their sample of researchers denounced strategic social behaviour in others, and claimed to be more altruistic themselves, they implicitly revealed that they too engaged with others in a calculated manner. Hence, when questioning researchers about their cooperative behaviour, it is important to find underlying patterns rather than relying solely on their own perception.

Reychav and Te'eni (2009) also studied academic knowledge exchange, but in the specific context of academic conferences. In line with gift exchange theory, the authors argue that researchers participate in conferences because they expect the exchange of knowledge to benefit their future research. They substantiate this idea using **social capital theory**, which describes how interpersonal relationships can generate value to those involved. To appreciate the full implications of social capital theory for coopetition, one should move the focus to the meso level.

Meso level analysis

Social capital can be defined in terms of three interrelated dimensions: structural, relational, and cognitive (Nahapiet and Ghoshal, 1998). The structural dimension relates to the superficial characteristics of (a network of) interactions, covering aspects like hierarchy, communication logistics, and network configuration in terms of direct ties between actors. The relational dimension covers, as the name suggests, the personal relationships developed through a history of interactions. These relationships provide motivations and context for the social motives typical to social networks, such as sociability, approval, and prestige. Lastly, the cognitive dimension is the most abstract one, relating to the resources that provide a common understanding, such as shared language, beliefs, and narratives. To understand and anticipate the behaviour of a group of people, all three dimensions need to be considered.

In their seminal discussion on the topic, Nahapiet and Ghoshal (1998) suggest that a shared history, frequent interactions, and a closed group structure contribute to the cultivation of social capital. This point is elaborated upon with the concept of **Communities of Practice** (CoP), introduced by Jean Lave and Etienne Wenger (Lave and Wenger, 1991). A CoP is defined as a group of practitioners connected through a shared domain of interest, who engage in activities and discussions with each other with the aim of learning together (Wenger, 2009). A CoP can therefore be a formally defined collective, such as a research department, but also an emergent one, like a network of researchers from different universities

investigating the same topic. Learning within a CoP is regarded as a communal enterprise, rather than an isolated process within the comprising individuals (Reychav and Te'eni, 2009).

Expanding the view further, coopetition can be studied from the collective behaviour of groups interacting at the inter-organisation level. Such intergroup dynamics (Kramer and Schaffer, 2015) are the central foci in the theoretical stream of the **network view**, which was popularised by Gulati et al. (2000). In their original paper, Gulati et al. discussed how firms' conduct and performance is influenced by their relationships with other organisational actors rather than by their internal resources and capabilities alone. Their notion that strategic networking can "potentially provide a firm with access to information, resources, markets, and technologies" illustrates the potential of coopetition.

Macro level analysis

Beyond the concrete individuals and relationships of the micro and meso level, the macro level describes more abstract social systems (Calhoun, 2014). In academia, it can pertain to the culture, the norms and practices, within academic disciplines or within academia as a whole. Fundamental to understanding this level are then the core academic values, formalised by sociologist Robert Merton in what became known as the four **Mertonian norms**: "communism, universalism, disinterestedness, and organized skepticism" (Merton, 1973). Although these norms are under debate due to their idealistic nature and the dated sociopolitical context in which they were developed, they are still popular as a guide for proper academic practice (Hosseini et al., 2022). The norms of universalism and organised scepticism translate to the requirement of objectivity and critical scrutiny, respectively, for all scientific findings. These requirements are fulfilled through peer reviews, disclosure of conflicting interests, and fraud legislation. More relevant to coopetition are the norms of communism and disinterestedness. The first refers to the understanding that scientific findings "are a product of social collaboration and are assigned to the community" (Merton, 1973). This understanding is reflected in the priority system, the recognition-based incentive structure that evolved because the characterisation of knowledge as a public good limits the monetary incentives for conducting research. The lack of monetary incentives also ties in with the norm of disinterestedness, which refers to the pursuit of common goals rather than personal benefits. To safeguard this standard, authors are required to report funding agents as well as potential conflicts of interest. Together, these two norms motivate academic cooperation. Coopetition then arises at the intersection of old academic values and modern practice, as academic capitalism is on the rise (Kauppinen, 2012) and academia is becoming increasingly competitive.

4. Building on the theoretical framework

The preceding chapter provides an answer to the posed questions "How is coopetition defined in existing research?" and "What theoretical frameworks is existing coopetition research built on?". By incorporating academia-specific theory as well, the found information was used to take steps towards answering the research sub-question "What existing coopetition theory is relevant to bottom-up academic coopetition?" This effort is continued in the following discussion, which addresses the relevance of the established theoretical framework to the construction and execution of an empirical study on academic coopetition. An online survey was chosen as the method to fit the exploratory nature of the current study.

The theory underlines the **two-dimensional nature of coopetition**. Accordingly, the concepts of competition and cooperation were assessed separately in dedicated sections of the survey. Hence, while potential relationships between the two concepts were considered in the subsequent data analysis, there was no inherent assumption of an (inverse) correlation in the questions participants were presented with.

A distinction is made between **horizontal and vertical relationships** in current work on coopetition. One way in which this distinction can be extrapolated to academia is via the fundamental to applied sciences pipeline. Within one research field, horizontal coopetition would then occur between two fundamental or two applied scientists and vertical coopetition between a fundamental and an applied scientist. To cover these different dynamics without exceeding the scope of the current study, a research area was chosen in which many levels of the fundamental-to-applied pipeline can be found: microscopy. The survey was aimed at researchers in fields ranging from fundamental optical physics, to translational microscope engineering, to microscopy-aided cell, micro- and nanobiology.

A second distinction is made between bottom-up coopetition, in which higher-level coopetition arises through lower-level processes, and top-down coopetition, in which coopetition is embedded at a high level and affects lower-level behaviour. While both types are covered in existing literature on industry coopetition, coopetition is rarely considered to be initiated by individuals at the operational (i.e., non-executive) level. A possible explanation is that interpersonal relationships between employees at competing companies are guided by strict rules and strategies due to the commercial concerns, so that there is limited freedom for operational employees to initiate a cooperation with a competitor. The individual freedom of academic researchers can then be assumed to be higher, as this freedom is considered to be important to healthy academic practice (Niemczyk and Rónay, 2022). The choice was therefore made to focus the survey and the remainder of the current study on bottom-up coopetition originating from operational individuals.

This choice was necessary to remain within the scope of the current study, but as noted by Bengtsson and Kock (2014), a holistic view of coopetition requires the consideration of both bottom-up and top-down processes. This is no different for academic coopetition than it is for industry coopetition. It was therefore not forgotten, for example, that increasing commercialisation and strategic management are also present in academia.

Providing a critical note on the perspective of Bengtsson and Kock, and to the theoretical framework in general, it is important to remember that theoretical concepts like the different levels of coopetition analysis, and the direction in which coopetition develops between them, are artificial constructs: as

mere abstractions of human behaviour, they are helpful in guiding thoughts and communication about coopetition but should not be taken as absolute truths. Hence, the theories included in the multilevel framework in section 3.2 were used as a guide in developing the survey, but they were not taken as ground truths and, when appropriate, intuition was used in congruence to fit the human nature of the topic at hand. To give an example, the concept of communities of practice (CoPs) was found useful in studying meso-level coopetition. Explicitly incorporating this concept into the survey, however, would give a risk of biasing the respondents; instead, the theory on CoPs helped identify potential CoPs in academic environments and, subsequently, survey questions on peer interactions were designed in such a way that they would allow for the assessment of these potential CoPs. More uses of the theoretical framework in the development of the survey are described in the related paragraphs of section 5.

5. Survey methods

From the theoretical framework, an online survey was then designed and executed to empirically answer the main research question "How and why do academic researchers combine competition and cooperation in their relationships with fellow researchers?" In this survey, academic researchers' experiences with professional competition and cooperation were investigated.

Guided by the theoretical framework from Chapter 3, as explained in Chapter 4, the main research question was divided into sub questions:

- General peer contact
  - How often do academic researchers interact with other academic researchers with different affiliations?
  - How do academic researchers interact with other academic researchers with different affiliations?
- Competition
  - How competitive do academic researchers feel towards other academic researchers with different affiliations?
  - Why do academic researchers feel competitive towards other academic researchers with different affiliations?
- Cooperation
  - How much do academic researchers cooperate with other academic researchers with different affiliations?
  - Why do academic researchers cooperate with other academic researchers with different affiliations?
- Coopetition
  - How do academic researchers' competitive and cooperative behaviours and sentiments relate to each other?

This choice of sub questions is elaborated on further in section 5.2. The last sub question was not reflected explicitly in the survey questions, but rather relates to the data analysis. As explained in chapter 4, no relationship between competition and cooperation was assumed in the survey questions to avoid a bias towards the one dimensional view of coopetition.

5.1 Study population

Survey respondents were drafted based on three criteria:

1. They are professional academic scientists. This includes PhD students, postdoctoral researchers, assistant, associate, or full professors, and staff scientists; it excludes bachelor's and master's students and commercial R&D scientists. In line with the bottom-up approach chosen for the current study, university executives were not included in the study sample.
2. They are active in a microscopy-related research area. This criterion ranges from optical physics, to microscope engineering, to cell, micro- and nanobiology. By setting this criterion broad, the survey was used to investigate different types of researchers, as well as different intra- and intergroup interactions.

3. They are employed at Dutch universities. Strategic alliances are affected by national culture (López-Duarte et al., 2016), which would introduce an additional dimension to the data if researchers active in different countries were included. To fit within the scope of the current study, the survey was therefore confined The Netherlands. With its longstanding tradition of seminal microscopy research (Van Leeuwenhoek, Huygens, Zernike), microscopy is an active field of study here.

Potential candidates were invited through email and requested to forward this invite to any colleagues also fulfilling the three criteria. Additionally, the Dutch Society for Microscopy was contacted and email invites were sent to their members.

43 scientists responded to the survey: 19 early career researchers (ECRs; PhD students and postdoctoral researchers), 17 principal investigators (PIs; assistant, associate, and full professors), and 7 staff scientists (analysts, technicians, and data engineers). The distribution of academic ages (length of professional academic careers) is shown in Figure 5.1; the geographical distribution is shown is Figure 5.2. The full list of research fields, as given by the survey respondents, can be found in Appendix A.

26 respondents completed the survey; the remaining 17 answered only a sub-section of the questions. The partial surveys were included in the analysis of the completed sub-sections but excluded from cross-sectional analyses.

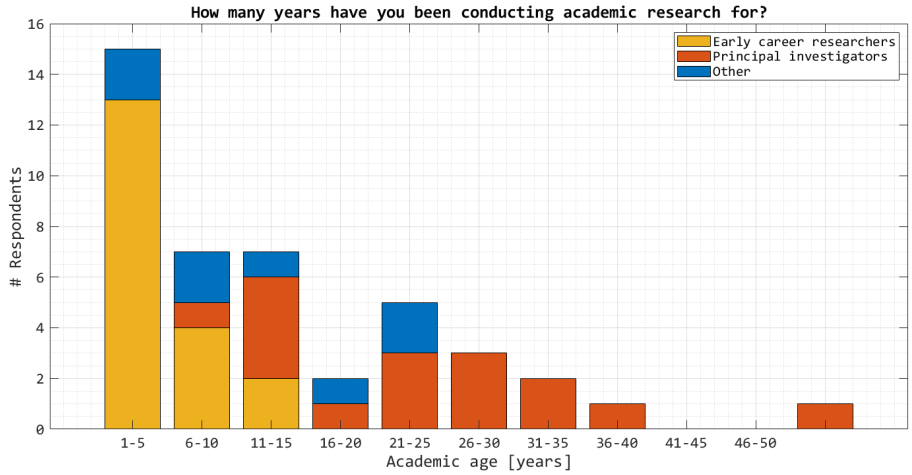

Figure 5.1: Survey respondents' answers to the question "How many years have you been conducting academic research for?".

Institute	# Respondents
Amsterdam Medical Center (AMC)	5
Delft University of Technology (TUD)	16
Leiden University (LU)	1
Leiden University Medical Center (LUMC)	2
Radboud University Medical Center (RUMC)	2
University Medical Center Groningen (UMCG)	2
University Medical Center Utrecht (UMCU)	1
University of Amsterdam (UvA)	1
Utrecht University (UU)	1
Vrije Universiteit Amsterdam (VU)	8
Wageningen University & Research (WUR)	1

Figure 5.2: The geographical distribution of the survey respondents

5.2 Survey

The survey was implemented in Qualtrics; it can be found in full in Appendix C. The survey was approved by the Human Resource Ethics Committee (HREC) to be in accordance with the TU Delft regulations on Human Trials. The approval documents included a Data Management Plan (DMP). The recorded data was backed up in a protected SurfDrive folder. Because the survey was anonymous, the respondents could not fill in an informed consent form and were presented with an opening statement instead (see Appendix B). Respondents had to explicitly state their understanding of and agreement with the statement before proceeding to the survey. As was stated in the Opening Statement, respondents were free to skip any questions they did not feel comfortable answering.

Career information

After agreeing with the opening statement, respondents were asked to supply the following information on their professional academic career:

- Their current employer;
- Their academic age;
- The duration of their career as an academic researcher;
- Their current research field;
- If applicable, their previous research field(s).

Work motivation

After this, a compressed version was included of the Measure of Motivational Sources by Ryan (2011). Respondents were asked to rate the contribution of the included motivational sources to their motivation for pursuing academic research, on a scale from "Does not motivate you" (1) to "Strongly motivates you"

(5). This section was included to allow for analysis of the relationship between general work motivation and specific competitive, cooperative, and coopetitive behaviour.

The rest of the survey was divided into three sections, one for each of the first three research sub question categories: general peer contact, competition, and cooperation. The questions on general peer contact were included to put the subsequently assessed competitive, cooperative, and coopetitive behaviour in perspective during the data analysis. The questions on competition and on cooperation were presented separately, in line with the two-dimensional view of coopetition, in which competitive and cooperative behaviours are placed on two separate axes rather than at the opposite ends of the same axis.

Peer contact

The respondents were asked about their interactions with fellow researchers, categorised by affiliation:

- respondents' own research group;
- other groups at respondents' own research department;
- other departments at respondents' institute;
- other academic institutes;
- non-academic institutes.

or by field of expertise:

- optics and imaging physics;
- computational microscopy;
- microscope engineering;
- cellular and micro-/nanobiology;
- blank space for respondent to fill in any other fields.

This double categorisation was included throughout the survey, but the second categorisation was discarded prior to the data analysis: it required categorisation of the respondents themselves into expertise groups as well, leaving groups too small for meaningful analyses.

The respondents were asked to scale the frequency of their interactions (in-person or digitally) from never (1) to weekly (5). They were then presented with six different types of interaction and asked to select which they had with the different peers:

- Casual meetings;
- Formal meetings;
- Networking events (eg., conferences);
- Direct messaging (e.g., email);
- Reading their publications;
- Social media;
- Other, with a blank space in which the respondents could write additional interaction types.

Lastly, the respondents were asked about their project collaborations with different peers. This question served a double purpose: to distinguish cooperation within and outside of the context of collaboration during data analysis, and to make the respondents more aware of the difference between collaboration and cooperation.

Competition

The following section probed the "if", "why", and "how" of respondents' competitive sentiments towards their peers: respondents could rate their competitive feelings on a four-point Likert scale and use open text boxes to describe where they believe these feelings come from and how they affect their work.

Cooperation

The respondents' cooperative attitude was how they share five types of unpublished research information:

- Research ideas;
- Unsuccessful attempts;
- Preliminary results;
- Unpublished data;
- Pre-prints.

This information is a relatively personal resource, compared to resources like equipment and facilities, and sharing it is relatively personally motivated, compared to sharing final results in formal publications. The focus on unpublished research information therefore fits within the current study's overall focus on individual researchers and bottom-up processes.

For each information type, the respondents could rate how often they share it with different peers ("Never", "Yearly","Several times a year","Monthly","Weekly") and how comfortable they do or would feel doing so (very uncomfortable (1) to very comfortable (4)). Open text boxes were included to allow the respondent to elaborate on their ratings.

5.3 Data analysis

The survey consisted mostly of Likert-scale questions, resulting in ordinal data. Ordinal data has a natural order, but the answers are categorical rather than quantitative and, as such, do not necessarily have defined nor equal distances between the responses; consider, for example, the response item sequence "Never", "Rarely", "Regularly", and "Frequently". The ill-defined intervals between the response items limit the descriptive statistics that can be used to analyse the data. To find the central tendency, no mean value can be computed because the arithmetic operations required are not possible when the distances between response items are ill-defined or unequal. Instead, the mode or the median can be used: the mode is the most frequently appearing response and the median is obtained by ordering the combined responses by their natural order and taking the middle value.

For the same reason, the variance can not be calculated for ordinal data; the only meaningful measures of variability are the minimum and the maximum value and the range between them. In the current study, the choice was made to depict the variability graphically (e.g., Figure 6.1).

The ordinal nature of the data also has implications for the inferential statistics. Such statistics were used when answering the last research sub question, "How do academic researchers' competitive and cooperative behaviours and sentiments relate to each other?", where they allowed for comparisons between the data from competition and from cooperation questions.

The data can not be assumed to follow a normal distribution, as both the mean and the variance are ill-defined, so parametric tests are not appropriate. Instead, non-parametric tests have been used in the current study. To compare two sets of answers with the same response items, for example the answers

of ECRs and PIs to the same question, a suitable non-parametric test is the Wilcoxon rank sum test. The output of this test, the p-value, corresponds to the probability that the two sets of answers follow the same distribution. The null hypothesis, that the sets indeed follow the same distribution, is rejected when p is smaller than 0.05; the difference between the sets is then said to be statistically significant. All Wilcoxon rank sum tests were executed with `MATLAB` function `ranksum`.

Wilcoxon rank sum tests could not be used for cross-sectional analyses, because the response items for questions in different sections were different or otherwise incomparable. Answer sets from different questions were therefore processed together using ordered logistic regressions (logits), which do not require continuous input variables. The regressions were performed with `MATLAB` function `mnrfit`. Setting the "model" to "ordinal", this function executes the regression according to the equation

$$\ln \frac{P(Y \leq y)}{P(Y > y)} = \epsilon_y + \beta \cdot X \tag{5.1}$$

describing that the logarithm of the ratio of the probability that the dependent variable Y is lower or equal to a particular value y to the probability that Y is higher than this y value is given by the sum of the regression constant for this value ϵ_y and the product of the regression coefficient β with the independent variable X. Following this equation, a unit change in the independent variable X impacts the odds of getting a lower dependent variable Y by a factor e^{β}, so that a negative β predicts that a higher X increases the odds of getting a higher Y while a positive β predicts that a higher X increases the odds of getting a lower Y.

6. Survey results

6.1 Work motivation

43 respondents rated six sources of work motivation from 1 ("Does not motivate you") to 5 ("Strongly motivates you"). The resulting distributions are shown in Figure 6.1.

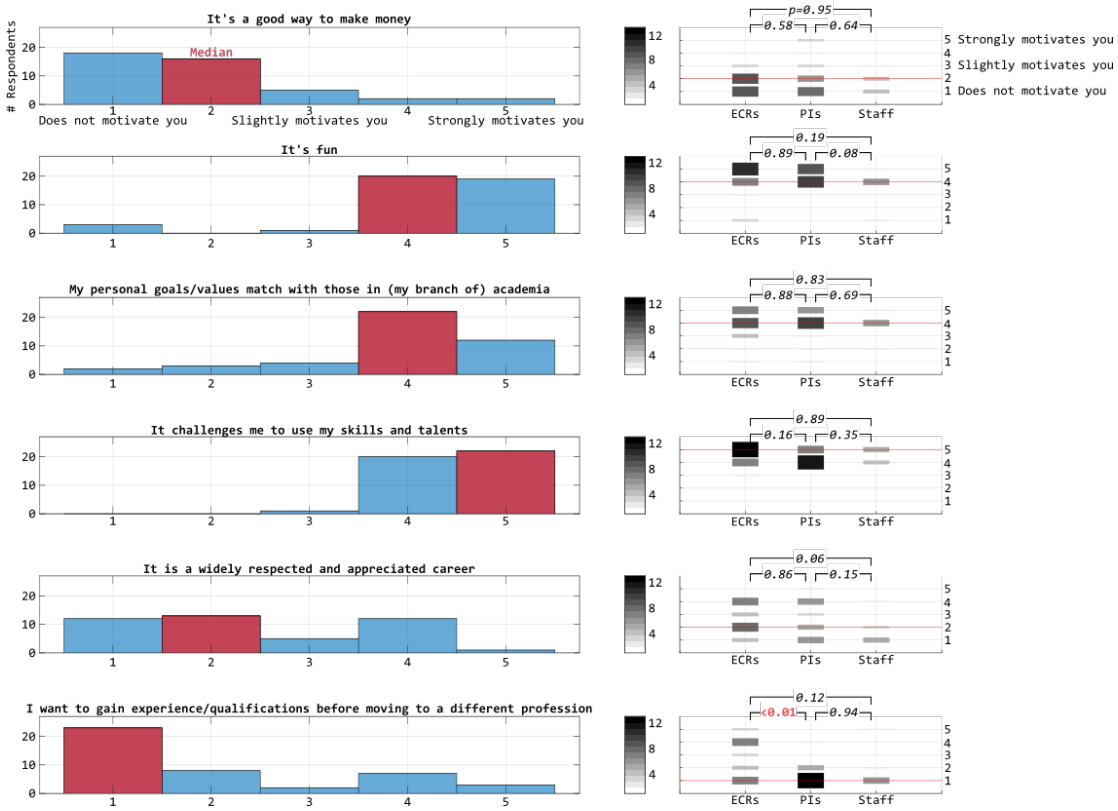

Figure 6.1: Work motivation in professional academic researchers. *Respondents scored how strongly six different motivations motivate their work in academic research. The histograms on the left show the combined results of all respondents, with the median score indicated by the red bar. The plots on the right show the results per academic rank group; the overall median is indicated by the red line and the width and darkness of the stripes correspond the number of respondents. The numbers above the rank group plots are the p-values from a Wilcoxon rank sum test between the distributions of two rank groups.*

Ranked from highest to lowest median value of the respondents' ratings, the motivations are

1. **"It challenges me to use my skills and talents"**
   Median rating: 5
   Internal self-concept motivation
2. **"It's fun"**
   Median rating: 4
   Intrinsic process motivation
3. **"My personal goals/values match with those in (my branch of) academia"**
   Median rating: 4

Goal internalisation motivation

4. **It is a widely respected and appreciated career"**
   Median rating: 2
   External self-concept motivation
5. **"It's a good way to make money"**
   Median rating: 2
   Instrumental motivation
6. **"I want to gain experience/qualifications before moving to a different profession"**
   Median rating: 1
   Instrumental motivation

The plots on the right of Figure 6.1 show the answer distributions for each academic rank group (ECRs, PIs, staff) separately. As indicated by the width and the darkness of the stripes, the ECRs appear to rate each motivation higher than the PIs and the staff. This is especially noticeable for "It's fun", "It challenges me to use my skills and talents", and "I want to gain experience". Wilcoxon rank sum tests between all the separate distributions, however, revealed that the only statistically significant difference between the rank groups was found for the latter motivation, which was scored higher by ECRs than PIs ($p < 0.01$). A near-significant difference was found between the ECR and the staff distribution for "It's a widely respected and appreciated career" ($p = 0.06$).

6.2 Interactions

39 survey respondents (17 ECRs, 16 PIs, 6 staff) completed the section on interactions with fellow researchers. The frequency of interactions is plotted per peer affiliation group in the histograms in Figure 6.2. Nearly all respondents indicated being in weekly contact with researchers at their own research group. The interaction median was also "weekly" for contact with researchers at other groups at the same department, but the spread in answers was larger here, with a substantial peak at "monthly". The median decreased further and the spread increased further as the peer distance increased, with a median of "monthly", but a shared mode of "monthly" and "weekly", for other departments at the same institutes, a median of "monthly" with a similar peak at "several times a year" for other academic institutes, and a median of "several times a year", but a shared mode of "several times a year" and "never", for non-academic institutes.

The results are grouped by academic rank on the right of Figure 6.2. With the exception of interactions with their own research group, ECRs are seen to have reported less frequent interactions with other researchers than PIs and staff did; the PI and staff median mostly correspond to the overall medians. The difference in answer distributions between ECRs and staff was confirmed to be significant by a Wilcoxon rank sum test ($p < 0.05$ for all but the own research group distribution). The ECR and PI distributions were only significantly different for the other academic and non-academic institutes (both $p < 0.01$); for the same department and same institutes, the difference was not significant ($p = 0.07$ and $p = 0.14$, respectively) but the plots do suggest a lower median and larger spread for the ECRs.

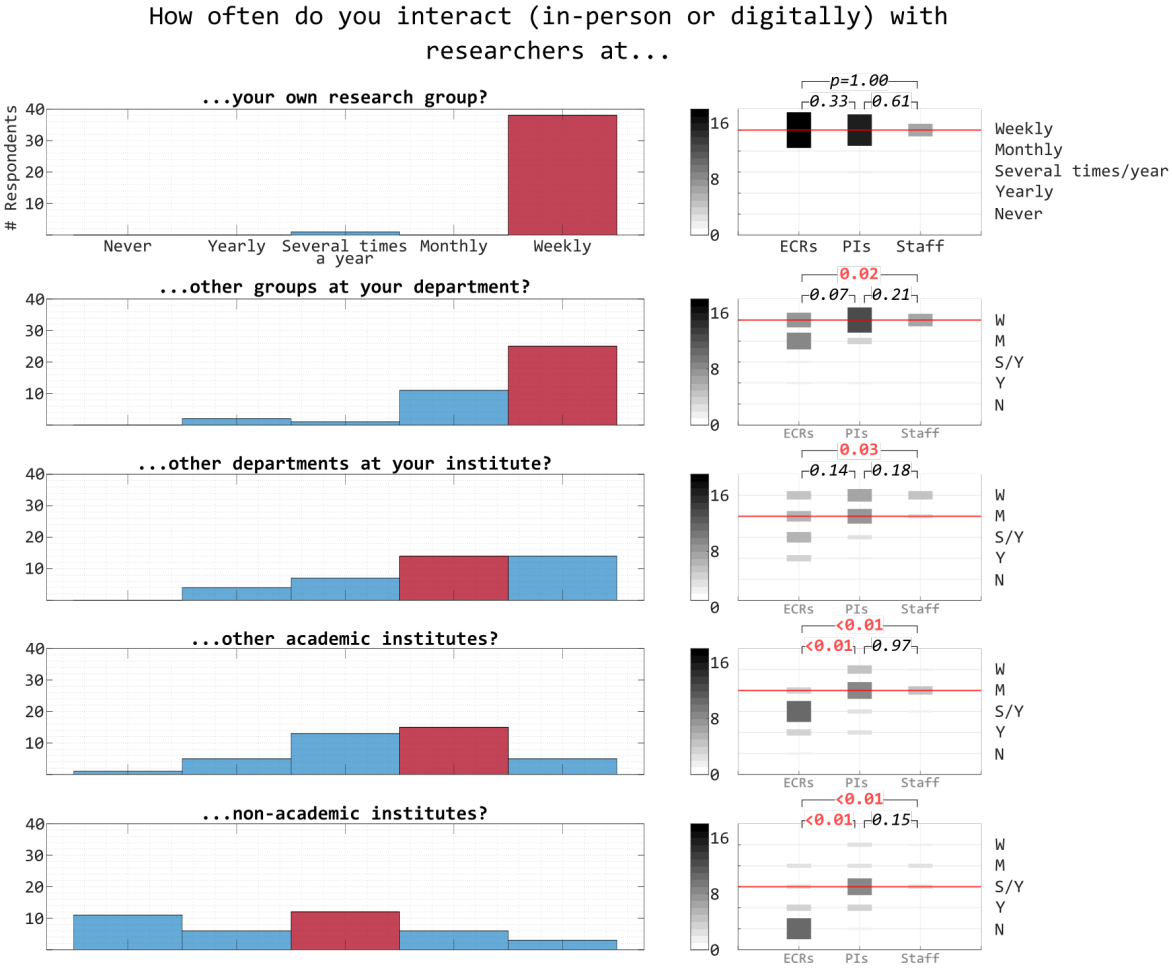

Figure 6.2: Answers to the question "How often do you interact (in-person or digitally) with researchers at..." *The histograms on the left show the combined results of all respondents, with the median score indicated by the red bar. The plots on the right show the results per academic rank group; the overall median is indicated by the red line and the width and darkness of the stripes correspond the number of respondents. The numbers above the rank group plots are the p-values of a Wilcoxon rank sum test between the distributions of two rank groups, with the significant values ($p < 0.05$) marked in red.*

6.3 Competition

34 survey respondents (14 ECRs, 15 PIs, 5 staff) answered the questions on competitive feelings. The distributions of their feelings towards researchers with different group, departmental or institutional affiliation are shown in Figure 6.3 (left). The response median and mode to the question "Do you feel competitive towards researchers at..." was "Not at all" towards researchers at the respondents' own research group (26 respondents), at other research groups at their department (25), at other departments at their institute (20), and at non-academic (e.g., commercial) institutes (25); there was no statistically significant difference between these answer distributions (all $p > 0.05$). For each peer affiliation group, the answer peaks consistently declined towards the more competitive answer options. The median for the competitive feelings towards researchers at other academic institutes fell between "Slightly competitive" and "Competitive", with the mode at "Competitive" (13 respondents), and the answer distribution was significantly different from those for the other peer affiliations (all $p < 0.01$).

The results per academic rank group are plotted on the right of Figure 6.3. The answer distributions appear similar for the own research group, other academic institutes, and non-academic institutes, as

confirmed by a Wilcoxon rank sum test ($p > 0.05$). The plots do suggest more competitive feelings of PIs, relative to ECRs, towards researchers at other groups at their department and at other departments at their institute, although these differences are not statistically significant ($p = 0.10$ and $p = 0.06$, respectively).

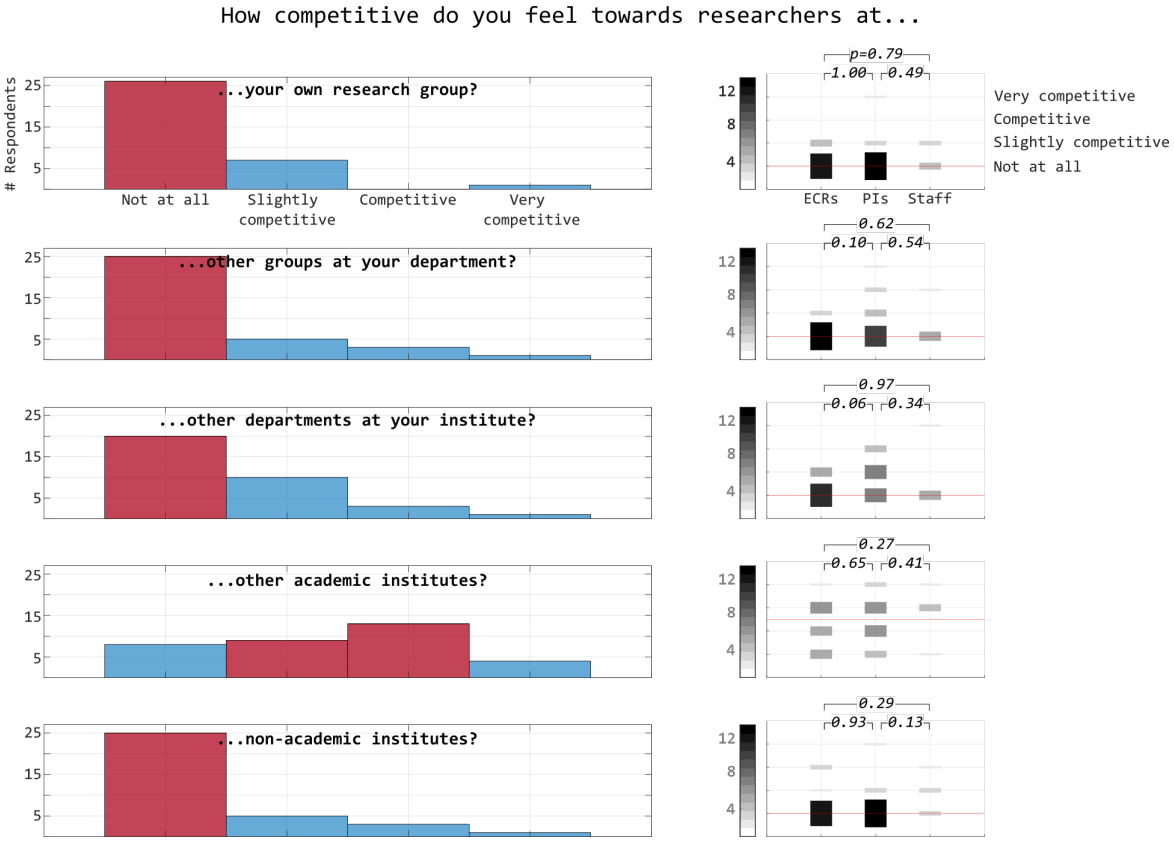

Figure 6.3: Answers to the question "Do you feel competitive towards researchers at..."*Respondents scored how competitive they feel towards researchers with different group affiliations. The histograms on the left show the combined results of all respondents, with the median score indicated by the red bar. The plots on the right show the results per academic rank group; the overall median is indicated by the red line and the width and darkness of the stripes correspond the number of respondents. The numbers above the rank group plots are the p-values of a Wilcoxon rank sum test between the distributions of two rank groups.*

The regression coefficients β and corresponding p-values of an ordered logistic regression (ordered logit, equation 5.1) with the different work motivations as the independent variables and the competition felt towards other researchers as the dependent variables are given in Table 6.1. An increased score for the motivation "It's fun" was found to predict lower competitive feelings towards researchers at other departments at the respondents' own institutes ($\beta = 0.73$, $p = 0.03$). Although not significant, the same prediction is suggested for competition towards researchers at respondents' own research groups ($\beta = 0.49$, $p = 0.28$), at other groups at their department ($\beta = 0.35$, $p = 0.30$), and at other academic institutes ($\beta = 0.58$, $p = 0.08$). An increased score for the motivation "My personal goals/values match with those in (my branch of) academia" predicts lower competitive feelings towards researchers at other academic institutes ($\beta = 0.80$, $p = 0.03$). Although not significant, the same prediction is suggested for competition towards researchers at other groups at the respondents' department ($\beta = 0.40$, $p = 0.35$) and at non-academic institutes ($\beta = 0.49$, $p = 0.28$).

Additionally, non-significant predictions that are shared across peer affiliation groups are an increase in competition with a higher score for "It's a good way to make money", an increase in competition with

a higher score for "It challenges me to use my skills and talents", and an increase in competition with a higher score for "It is a widely respected and appreciated career".

Lastly, while not statistically significant, the regression results suggest that the motivation to gain experience/qualifications before moving on to a different profession increases the competition felt towards researchers at the respondents' own group ($\beta = -0.59$, $p = 0.14$) but decreases the competition felt towards researchers at non-academic institutes ($\beta = 0.66$, $p = 0.17$).

	What are your motivations for doing academic research?	It's a good way to make money		It's fun		My personal goals/values match with those in (my branch of) academia		It challenges me to use my skills and talents		It is a widely respected and appreciated career		I want to gain experience/qualifications before moving to a different profession	
Do you feel competitive towards researchers at…		β	p	β	p	β	p	β	p	β	p	β	p
...your own research group?		-0.64	0.22	0.49	0.28	-0.23	0.73	-1.93	0.11	0.35	0.45	-0.59	0.14
...other groups at your department?		-0.45	0.33	0.35	0.30	0.40	0.34	0.41	0.64	-0.40	0.28	-0.10	0.76
...other departments at your institute?		-0.66	0.11	**0.73**	**0.03**	0.24	0.52	0.25	0.74	-0.31	0.33	-0.09	0.74
...other academic institutes?		0.00	0.99	0.58	0.07	**0.80**	**0.03**	-1.12	0.10	-0.35	0.24	0.24	0.36
...non-academic institutes?		0.03	0.95	0.07	0.85	0.49	0.28	-1.41	0.16	-0.17	0.68	0.66	0.17

Table 6.1: The coefficients β and corresponding p-values for an ordered logit with the work motivations as independent variables and the competition felt towards other researchers as dependent variables. *A negative β (blue) suggests that an **increase** in the work motivation predicts a **increase** in the felt competition; a positive β (red) suggests that an **increase** in the work motivation predicts an **decrease** in the felt competition. Statistically significant results are indicated with thick black borders; shared trends across peer affiliation groups are indicated with dashed black borders.*

21 respondents (8 ECRs, 9 PIs, 4 staff) elaborated on why they do or do not feel competitive towards other researchers and how this affects their work. As the source of their competitive feelings, ten of them stated a fear of other researchers publishing about the same topic before they do, mainly other researchers at other academic institutes. Succinctly summarised by one respondent, they are "in competition with them to publish similar data." Five respondents explicitly quoted the competition for funding as chief contribution to their competitive sentiments, saying that "everyone is competing for the same limited funding and resources." Two respondents invoked the comparison with close colleagues, saying that they "feel slightly competitive to people in my department who are not on the same research, because I think others will compare my accomplishments to theirs" or that "doing less than my direct colleagues doesn't sit right for me". Lastly, two respondents felt a responsibility towards their group or institute, saying that they "want my group to perform and [be] recognized" and that they are "working to make sure the [institute] and our group stay up there."

Nine respondents indicated that competition had a positive effect on their research, for example saying that "it drives creativity and critical thinking", "it keeps me focused on the most important research themes", and that "in the past they have improved my research". Some did nuance their answer, describing the effect of competition as "mostly positive" but that " some competitive occasions like grant applications can be stressful", or saying that "it can make me doubt myself". Ten respondents described a negative impact of competition on their work, often quoting the time pressure arising from it. One respondent explained that they "find competition mostly counterproductive for creativity, reduces the quality of work, and produces negative feelings between colleagues." In line with this last point, another respondent said that competition "makes [it] difficult to start projects together."

6.4 Sharing information

20 survey respondents completed the section on sharing unpublished information (8 ECRs, 11 PIs, 1 staff). The data on sharing pre-prints was excluded from analysis as various respondents either omitted

this question or indicated that they considered this published information. The reported frequencies of and comfort levels with sharing are combined in the 2D histograms in Figure 6.4. The histograms for sharing different information types with researchers of the same group affiliation appear similar, and a series of Wilcoxon rank sum tests confirmed that per peer affiliation group, neither the sharing frequency nor the sharing comfort follow significantly different distributions for the different information types ($0.13 < p < 1.00$). For analysis with higher numbers, these distributions were therefore combined for each peer affiliation group in the histograms on the right in Figure 6.4. The median value of both the sharing comfort and the sharing frequency was highest with researchers at the respondents' own research group, and decreased as the distance to the peer group increased:

- **Own research group:** Very comfortable, Weekly sharing;
- **Other groups at your department**: Very comfortable, Monthly sharing;
- **Other departments at your institute**: Slightly comfortable, Sharing several times a year;
- **Other academic institutes:** Slightly comfortable, Sharing several times a year/yearly;
- **Non-academic institutes:** Slightly uncomfortable, Yearly sharing.

Correspondingly, ordered logits with peer group affiliation as the independent variable and sharing comfort or sharing frequency as the dependent variable indicated that increased peer group distance is associated with decreased comfort with ($\beta = 0.95$, $p < 0.001$) and frequency of sharing ($\beta = 1.22$, $p < 0.001$). Additionally, the spread in answers increases as the peer distance increases, with the most uniformity in answers for sharing with the own research group and the highest variance among answers for sharing with non-academic institutes.

Different than the sharing comfort and sharing frequency distributions per peer affiliation group between information types, the distributions per information type for different peer affiliation groups did have significant differences. The p-values from a Wilcoxon rank sum test are reported in Table 6.2. These values indicate that, with the peer affiliation groups ordered same group - same department - same institution - other academic institutions - non-academic institutions,

- the sharing comfort followed a significantly different distribution for nearly all non-adjacent peer affiliation groups;
- the distributions of the sharing frequency with the respondents' own research group and with other groups at their department differed significantly from those of all other peer affiliation groups;
- for the remaining peer affiliation groups, the sharing frequency followed a significantly different distribution for most non-adjacent peer affiliation groups.

These 2D histograms for the different peer affiliation groups are combined per information type in the histograms on the bottom in Figure 6.4. In line with the results of the ordered logit, which predicted a similar impact of peer group affiliation on sharing comfort and frequency, these combined histograms show the largest concentration of answers along the main diagonal, which corresponds to similar levels of comfort with and frequency of sharing. Some answers are also located below this diagonal, corresponding to higher comfort with than frequency of sharing. The lowest concentration of answers is above the diagonal, which indicates lower comfort with than frequency of sharing.

18 respondents (9 ECRs, 8 PIs, 1 staff) elaborated on their reasons behind their sharing behaviour. The motivations for sharing their unpublished research information could be categorised into three main groups:

- **Greater scientific good**
  Ten respondents shared the sentiment succinctly summarised by one as "Being open bring science

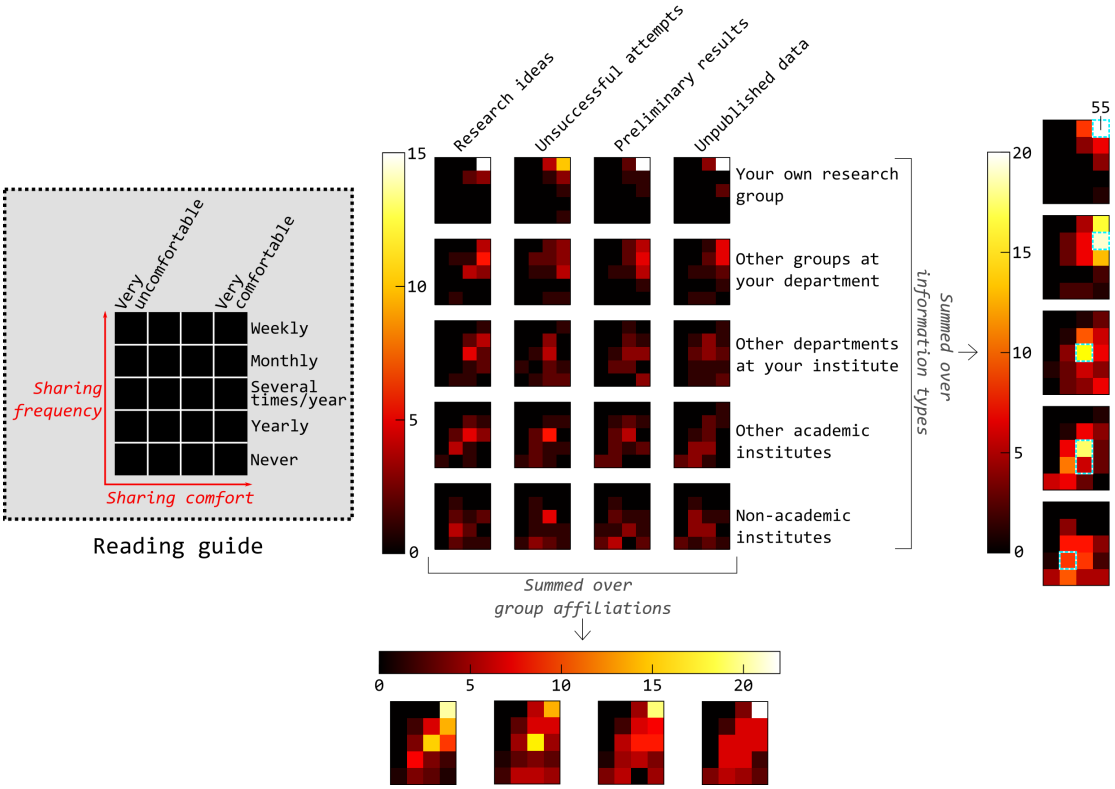

Figure 6.4: The respondents' answers to the questions "How often do you share your [information type] with researchers at [peer affiliation]?" and "Do or would you feel comfortable sharing your [information type] with researchers at [peer affiliation]?" *Points along the diagonal of the histograms correspond to similar levels of comfort with and frequency of sharing; above the diagonal, the frequency of sharing is higher than the comfort level; below the diagonal, the comfort with sharing is higher than the frequency. (Right) The combined 2D distributions for all information types, per peer affiliation group. The dashed blue squared indicate the median values. The colour bar is clipped at* 20*, thereby not covering the peak value of* 55 *for sharing with the own research group. (Bottom) The combined 2D distributions for all peer affiliation groups, per information type.*

further." Regarding information on unsuccessful attempts, one respondent elaborated that they "think that unsuccessful experiments are highly underestimated in our current academic society. While everyone is to some level aware that "failed" experiments can contain a lot of information, there are no real platforms to communicate them (while for "successful" experiments, we have papers)." Some respondents did nuance their answers, stating that they are "generally in favour of open science, I am only a slight bit concerned about unpublished technical ideas being taken and published before I can, so my work will be harder to publish", and that they "would only share less with people that I know less." Additionally, one person opposed the view of contributing to science through common sharing, specifically through sharing information on unsuccessful attempts, stating that this practice "not always help building a better research environment".

- **Receiving feedback**

  Five respondents underscored the value of receiving feedback. As one respondent stated, "It's important to discuss what we are doing. It's a lot easier to figure out the answer to a problem if you crowdsource." Another shared their experience with discussing preliminary results, stating that "it happened several times that external help pushed a project forward".

- **Helping others**
  Five respondents explained being willing to share information on their unsuccessful attempts in order to "help other parties to avoid my mistakes". In line with the sentiments regarding the greater scientific good, one respondent explained how "Failed attempts are just part of science, and are incredibly valuable to share (maybe just as valuable as success stories). If we don't share our non-successes, this may just lead to someone else making all the same mistakes that you have already learned about, and are therefore unnecessary and a waste of time."

Additionally, someone shared the intrinsic process motivation that "Preliminary results are often exciting and promising, and fun to share". Another person included the benefit that sharing research information "potentially creates new cooperations".

The reasons given for withholding information could also be categorised into three main groups

- **Competition**
  Ten respondents felt apprehensive about sharing their unpublished research information due to competitive feelings, most commonly due to a fear of having their ideas and results stolen. A distinction was regularly made between the feelings towards different peer affiliation groups, with answers like "We have a very open, friendly and non-competitive environment within our department. I don't know people outside my department very well so then I feel less comfortable in sharing" and "I don't feel competition within my research institute but I do feel it outside".

  Some respondents expressed reservations due to commercial considerations, for example saying that only "not patentable materials can be discussed" or that they don't share with non-academic researchers as "some results might lead to commercial opportunities for me and my collaborating colleagues". Of note, the respondent sharing the latter reason earlier stated not to feel at all competitive towards non-academic researchers.

- **Fear of judgement**
  Four respondents gave a fear of judgement as a reason to abstain from sharing information, especially information on unsuccessful attempts. Two of them felt comfortable sharing with their own research group but reluctant to go beyond, explaining that they feel "like one can looses his/her face within the institute or other departments, [while] the own research group is a safer place." Conversely, the other two respondents feared judgement from their own groups, saying that they "don't want them to think that everything goes wrong" and that they "worry more experienced staff will judge me for making mistakes/unsuccessful attempts." Another respondent did recognise the fear of judgement as a potential obstacle to sharing unsuccessful experiences, but did not experience it themselves, by stating that they are "not easily ashamed".

- **Quality concerns**
  Five respondents shared concerns regarding the quality of preliminary results and unpublished data, especially when spread out of context. They worried "that preliminary results will change, because of optimization that needs to be done" and "would not share some data that could be misleading without the proper context like as presented in a paper." One of the respondents made a distinction between different peer affiliation groups, saying that "as long as there is a good reason for sharing these [preliminary] results, I would feel comfortable doing so. But outside of our institute I would be a bit more careful as you don't want it to be interpreted the wrong way."

More ambiguously, three respondents stated the importance of trust, explaining that "mutual trust is important for progress". The presence or absence of trust can affect sharing behaviour, as one respondent felt that they "can safely share results and finding across [their own institute], I don't know whether people outside the [institute] are that trustworthy."

Sharing comfort

Research ideas

	Your own research group	Other groups at your department	Other departments at your institute	Other academic institutes
Other groups at your department	0.06			
Other departments at your institute	p<0.01	0.40		
Other academic institutes	p<0.01	p<0.01	0.02	
Non-academic institutes	p<0.01	p<0.01	p<0.01	0.42

Sharing frequency

Research ideas

	Your own research group	Other groups at your department	Other departments at your institute	Other academic institutes
Other groups at your department	p<0.01			
Other departments at your institute	p<0.01	0.04		
Other academic institutes	p<0.01	p<0.01	0.33	
Non-academic institutes	p<0.01	p<0.01	p<0.01	0.02

Sharing comfort

Unsuccesful attempts

	Your own research group	Other groups at your department	Other departments at your institute	Other academic institutes
Other groups at your department	0.13			
Other departments at your institute	p<0.01	0.14		
Other academic institutes	p<0.01	0.01	0.10	
Non-academic institutes	p<0.01	0.01	0.10	0.94

Sharing frequency

Unsuccesful attempts

	Your own research group	Other groups at your department	Other departments at your institute	Other academic institutes
Other groups at your department	0.01			
Other departments at your institute	p<0.01	p<0.01		
Other academic institutes	p<0.01	p<0.01	0.85	
Non-academic institutes	p<0.01	p<0.01	0.19	0.22

Sharing comfort

Preliminary results

	Your own research group	Other groups at your department	Other departments at your institute	Other academic institutes
Other groups at your department	0.25			
Other departments at your institute	p<0.01	0.08		
Other academic institutes	p<0.01	p<0.01	0.02	
Non-academic institutes	p<0.01	p<0.01	0.01	0.69

Sharing frequency

Preliminary results

	Your own research group	Other groups at your department	Other departments at your institute	Other academic institutes
Other groups at your department	p<0.01			
Other departments at your institute	p<0.01	p<0.01		
Other academic institutes	p<0.01	p<0.01	0.67	
Non-academic institutes	p<0.01	p<0.01	0.03	0.08

Sharing comfort

Unpublished data

	Your own research group	Other groups at your department	Other departments at your institute	Other academic institutes
Other groups at your department	0.13			
Other departments at your institute	p<0.01	0.06		
Other academic institutes	p<0.01	p<0.01	0.05	
Non-academic institutes	p<0.01	p<0.01	0.03	0.73

Sharing frequency

Unpublished data

	Your own research group	Other groups at your department	Other departments at your institute	Other academic institutes
Other groups at your department	p<0.01			
Other departments at your institute	p<0.01	0.02		
Other academic institutes	p<0.01	p<0.01	0.18	
Non-academic institutes	p<0.01	p<0.01	0.02	0.42

Table 6.2: The p-values from a Wilcoxon rank sum test between the peer affiliation group distributions for behaviour *The p-values from a Wilcoxon rank-sum test between the different peer affiliation groups' answer distributions to the questions "Do or would you feel comfortable sharing your [information type] with researchers at..." (sharing comfort, left) and "How often do you share your [information type] with researchers at..." (sharing frequency, right). Blue indicates significant differences ($p < 0.05$), red indicates non-significant differences ($p \geq 0.05$).*

7. Survey discussion

The concurrence of competition and cooperation between academic researchers was investigated using an online survey, which was informed by a literature search on the topic. The results of the survey, which was distributed among academic microscopy researchers, indicated that these researchers feel competitive towards peers at other academic institutes. Correlations were found between the respondents' overall competitive sentiments and their motivations for pursuing a career in academics, with the presence of instrumental and self-concept motivations predicting a higher sense of competition, and intrinsic process and goal internalisation motivations a lower sense. While most respondents felt non-competitive towards researchers at their own institute and at non-academic institutes, they did feel less comfortable sharing unpublished research information with more distant peers. In practice, they also shared this unpublished information less as their distance to the receiving researcher increased, as also predicted by decreased overall interaction frequency with increasing peer distance.

The correlations found between researchers' general work motivations and their competitive feelings suggest that the rivalry researchers feel towards fellow researchers is tied to their reasons for pursuing a career in academics. This finding, if verified statistically in an upscaled follow-up study, can be used to inform incentive structures for academic cooperation and collaboration. Currently, incentive programmes for prosocial behaviour in academia mainly provide extrinsic motivations, such as financial rewards (Mons et al., 2017). The results from the current study predict that such incentives mostly motivate those with a competitive attitude. This could be desirable, as competitive researchers may require the most external motivation to engage in cooperative behaviour. If the aim, however, is to attract researchers who feel little rivalry towards others, it may be more effective to base incentive structures on the work motivations associated with low competitive attitudes. Hence, the relationships between work motivations and competitive feelings can be used to inform incentive structures for prosocial academic behaviour, to adjust them to their intended audience.

In general, a move away from purely extrinsic, instrumental incentivisation towards identifying and building on intrinsic motivations for prosocial academic behaviour is advisable, firstly because instrumental motivations were found to be the weakest work motivator, in line with the findings of Ryan (2014), and secondly because personal motivations are argued to be imperative for sustainable cooperation in academia (Altenmüller and Gollwitzer, 2022).

As mentioned before, reservations towards these findings and suggestions are in place, not only due to the small sample size, but also due to potential method biases. Because the survey respondents self-reported both their work motivations and their competitive sentiments, with limited room to elaborate, no distinction can be made between their true behaviour and feelings on one side and how they perceive or wish to perceive themselves on the other. It is therefore possible that the reported levels of competition are more reflective of what the respondents deem appropriate than of what they actually experience. This potential bias is elaborated on later on in this discussion.

Sharing unpublished research information was chosen as a measure of cooperation. Both the respondents' comfort with and their frequency of sharing such information was found to decrease with increasing peer distance, while no correlation was found between peer distance and general competitive feelings: most survey respondents claimed not to feel competitive towards other researchers regardless of peer

distance, with the exception of peers at other academic institutes. These two results together showcase the two-dimensional nature of coopetition, which allows for an increase in either competition or cooperation without a concomitant decrease in the other, and vice versa.

This is not to say that competitive feelings do not influence cooperative behaviour. Indeed, the motivations given by the respondents for their reluctance to share information included competitive sentiments. Anecdotal yet notable is the respondent who did not feel comfortable sharing preliminary results with non-academic researchers, as they might themselves want to commercialise their findings, yet earlier stated that they did not feel at all competitive towards non-academic researchers. One explanation for this discrepancy is that this respondent does not characterise their desire to be the first to commercialise their ideas as a competitive feeling. Generalising this explanation, the lack of reported competition in spite of potentially competitive reluctance to share information illustrates the importance of accounting for the diverse interpretations of competition, and related concepts, when assessing individuals' perspective on them.

Researchers' divergence from textbook definitions of competition could stem from a cognitive dissonance. Fitting under the umbrella of bounded rationality, cognitive dissonance "is produced when one person has two cognitive elements that are inconsistent with each other" (Carpenter, 2019). In the current discussion, one of these elements is the researchers' self-concept in relation to competition: how they perceive their own competitive attitude. A common understanding is that individuals aim to maintain a positive self-concept (Carpenter, 2019). Because in academia competition can carry a negative connotation, as it opposes the classic norms of communism and disinterestedness, academic researchers may therefore reject or downplay their own competitive feelings. Actions and sentiments that could be characterised as competitive then cause cognitive dissonance, motivating the concerning researcher to reduce the dissonance by not recognising these actions and sentiments as competitive, either consciously or subconsciously.

Besides providing a challenge when studying academic relationships, the ambiguity in defining and experiencing academic competition could complicate the development of these relationships. On an individual level, with researchers planning their interactions with colleagues, or at a group level, with group managers devising formal interaction strategies with other organisations, it is therefore advisable to first investigate how the researchers involved both define and personally experience competition and cooperation, and potentially uncover underlying competitive sentiments. To this end, a dual purpose tool was designed: using an interactive interface, users can explore the ambiguous concepts of competition and cooperation and their relation to them; subsequently, the results can be consulted by and discussed with their group managers, upon which interaction strategies can be fine-tuned to fit the researchers involved. This tool is explained in detail in the following chapter.

8. GICCo: Guide for Introspection on Competition and Cooperation

The key finding of the current study was the discrepancy between the reported competitive sentiments and the competition-driven reluctance with sharing research information. This discrepancy may in part be explained by a cognitive dissonance in the study participants, keeping them from recognising their own competitive feelings. This cognitive dissonance could cause two main issues:

1. When these researchers interact with others, friction may arise due to underlying competition;
2. Designing and implementing an interaction strategy, for example by group managers, is difficult when the current interpersonal relationships and sentiments are unknown or incorrect.

The Guide for Introspection on Competition and Cooperation (GICCo) was developed to help prevent these issues. As a dual purpose tool, it invites users to reflect on their sentiments towards different types of peers and it serves as a starting point for discussions between researchers and their colleagues, supervisors, or managers on interpersonal sentiments and how these affect individual or group level interactions.

8.1 Design process

A succinct yet accurate model that can be used to summarise the GICCo design process is the four-stage model of design by renowned design researcher Nigel Cross (Figure 8.1) (Cross, 2021). Before elaborating on this, it should be noted that the Cross model is not the only appropriate process abstraction. As formulated before by Dubberly (2008) in reference to design models, "You can add more detail - dividing phases into steps and steps into sub-steps, almost infinitely." This is evidenced by the remainder of Dubberly's book, in which they include over 100 models for design processes and strategies, all with different levels of detail. While Cross' four-stage model will be used as an elegant guideline to concisely explain the design process, additional details and elements of other models will therefore be included when relevant. It is important to note that the application of Cross' model is retrospective: it is fit to the strategy applied to the GICCo design, not the other way around. Furthermore, the boundaries between the four different stages was in reality more fluid than the strict separations suggested by the diagrammatical representation in Figure 8.1.

The starting point of Cross' model, prior to the first stage, is a problem statement. In the current study, the "problem" was identified from the results of the literature search and the survey: academic competition and cooperation most likely have a two-dimensional relationship, so that one does not negate the other, but this may not be generally known or accepted, leading to discrepancies between researchers' actual and perceived competitive and cooperative sentiments.

Because this problem statement was already founded on exploratory study, it overlaps with the first stage of the model, "exploration". Indeed, the ill-defined problem space described by Cross as a starting point would be academic coopetitive tensions in general, and the exploration stage would refer to the convergence towards the discrepancies in particular.

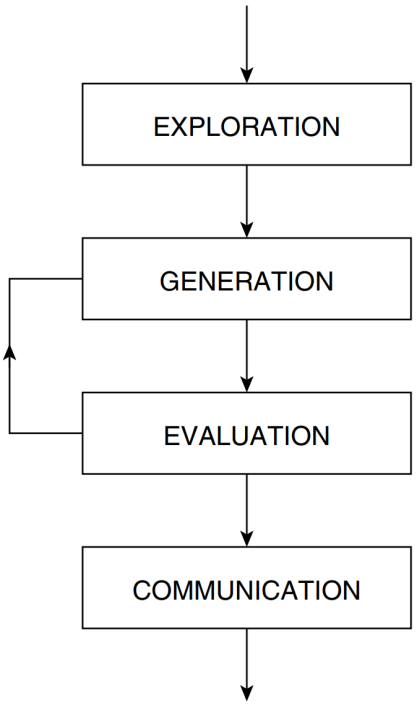

Figure 8.1: A simple four-stage model of the design process. *"I outlined what could be a simple descriptive model of the design process, based on the essential activities that the designer performs. The end-point of the process is the communication of a design, ready for manufacture. Prior to this, the design proposal is subject to evaluation against the goals, constraints, and criteria of the design brief. The proposal itself arises from the generation of a concept by the designer, usually after some initial exploration of the ill-defined problem space." Figure and caption by Cross (2021).*

The transition towards the "generation" stage was then marked by the initial idea from which GICCo was eventually developed. This initial idea was a passive visualisation, inspired by the two-dimensional relationship between competition and cooperation. In the visualisation, the two-dimensional plane between a competition and a cooperation axis would be divided into squares, so that each square would represent different absolute and relative levels of competition and cooperation. An elaborate legend would supplement the visualisation and give information on each of the squares. Users could then use the visualisation to learn more about the nuances of coopetition and find their place in the 2D space.

To further develop this idea, an iterative two-step feedback loop was initiated: individual development cycles were interspersed with duo brainstorms. The individual cycles were executed by the head researcher and were, additional to the previous study findings, largely guided by intuition and personal experience. This fits within the model of design developed by Archer (1984), which explicitly includes "interactions with the world outside of the design process itself, such as [...] the designer's training and experience" (Cross, 2021). One relevant experience was that academic researchers are usually very busy, so that they have limited time to dedicate to additional endeavours such as using a novel tool. Hence, regardless of the potential value of this tool to their work, using it should not take too long. This idea of the busy researcher was supported by the declining survey response rate (see section 5.1). The first design criterion was therefore that the time dedication for using the tool should ideally be fifteen to thirty minutes.

The ideas developed during the individual cycles were then discussed between the head researcher and the supervising researcher, the latter of whom could contribute with specialised knowledge from their career as a social scientific (design) researcher. Based on their experience, they pitched what became the second main design criterion: that the tool should be interactive.

The information discussed and ideas emerging from these duo sessions were then used as the foundation for a new cycle of individual development. At this point, the head researcher made a first draft of the tool in MATLAB.

The two-step feedback loop was repeated, and the design criteria were updated accordingly, until the tool design was found satisfactory by both the head and the supervising researcher.

The evaluation stage was then initiated. The intention of the evaluation was to check whether GICCo fit the design criteria and fulfilled the purpose for which it was built, i.e., made users more aware of the ambiguous relationship between academic competition and cooperation and help them reflect on their part in this. To this end, two prospective users were observed as they used the GICCo prototype, after which they were questioned about the experience and asked for feedback on the tool. The questions were writted beforehand and were devised to assess how well GICCo fit the design criteria and its general purpose.

As depicted in the Cross' four-stage model, a feedback loop exists between the evaluation step and the generation step. Indeed, the information obtained from the user evaluation sessions were used to update the GICCo prototype. This process was not repeated, as once was sufficient for the scope of the current study.

An attractive element of Cross' model, and a partial motivation for its inclusion in the current section, is the incorporation of "communication" as the final stage of the design pipeline. In the words of Cross himself, "perhaps it does not matter how the designer works, so long as he or she produces that final description of the proposed artefact." Applied by Cross to industrial design, this sentiment was deemed equally appropriate in the context of an academic study, in which the written output is often the main resource and therefore a crucial step in the design process.

8.2 Design criteria

The main criteria adhered to when designing and evaluating the GICCo prototype were that it had to be

- Quick
  Academic researchers are often very busy and may therefore be less willing to dedicate time to a novel tool, regardless of its potential value to their work. Using the tool should therefore take no longer than fifteen to thirty minutes.
- Interactive
  The purpose of GICCo is to invite people to investigate their own sentiments, not to just give information. It is therefore important that using the tool is not a passive experience. Additionally, GICCo addresses potential discrepancies between researchers' perceived attitudes towards competition and cooperation and how these attitudes are actually reflected by their actions. It should therefore assist the users in tangibly adjusting their perspective as they are using the tool.
- Unbiased
  GICCo is aimed at addressing the discrepancies between researchers' attitudes on competition, cooperation, and their role in these behaviours on one side, and the scientifically established theory on these concepts and how they typically manifest on the other side. To illustrate these discrepancies and how they may manifest in the individual users, it is then important that they start by giving an unbiased assessment of their own attitudes, i.e., without being presented the theory on competition and cooperation beforehand.
- Intuitive
  Partly because of the previous criterion of unbiased use, the GICCo interface should be intuitive,

i.e., easy to use without elaborate introduction and instruction.

Two feedback sessions were organised to investigate how well the GICCo prototype fulfils these criteria. Based on the received feedback, the prototype was improved to the version shown below. A report of the feedback sessions is given in section 8.4.

8.3 The GICCo prototype

To further explain GICCo and illustrate its prospective use, a prototype was developed in MATLAB based on the literature search and survey results of the current study. The corresponding code is included in Appendix D. The aim is to continuously develop GICCo as the body of literature on academic coopetition grows.

Users

The prospective principal users of GICCo are academic research scientists: the questions and information in the tool's interface are tailored to them based on both scientific theory and direct experiences from other researchers. The secondary users are more broadly defined to include anyone who professionally interacts with academic research scientists. This second group can observe the researchers as they navigate GICCo or they can use the tool's outcome to inform they decision making.

The GICCo prototype was devised from the results of the current study, so that the empirical aspects originate from researchers in microscopy-related fields. Before the tool can be used by other types of researchers, these aspects should therefore be tested for generalisability.

Step 1: Select peer group.

Users are first asked to set which peers they want to explore their sentiments towards (see Figure 8.2). They can choose from a drop-down menu with pre-set peer affiliation groups.

The prototype only includes researchers at different institutes. In future versions, peers with different affiliations can be added as well as peers in different research fields.

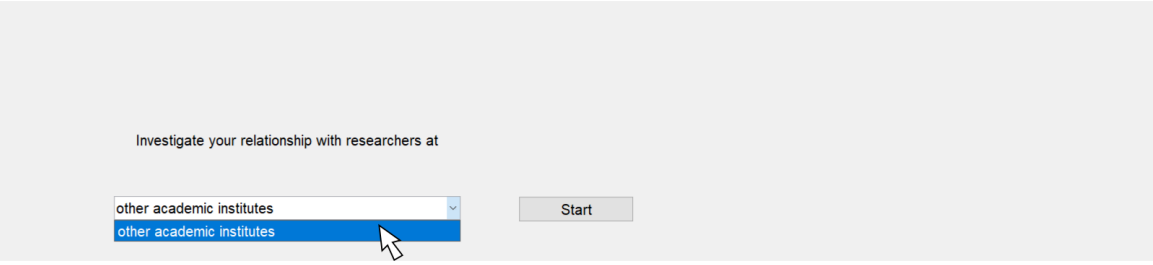

Figure 8.2: The user can select which group they want to explore their sentiments towards.

Step 2: Rate competition and cooperation.

Before any scientific theory on academic competition and cooperation is presented, the user can use sliders to indicate the level of competition and cooperation they feel towards their chosen peer type (see Figure 8.3). The aim is to establish the unbiased ground levels. Below the sliders are two boxes with text requesting the user to move the sliders in order to receive information on competition (left box) and cooperation (right box). The text also mentions that the user is free to adjust the sliders after receiving the information.

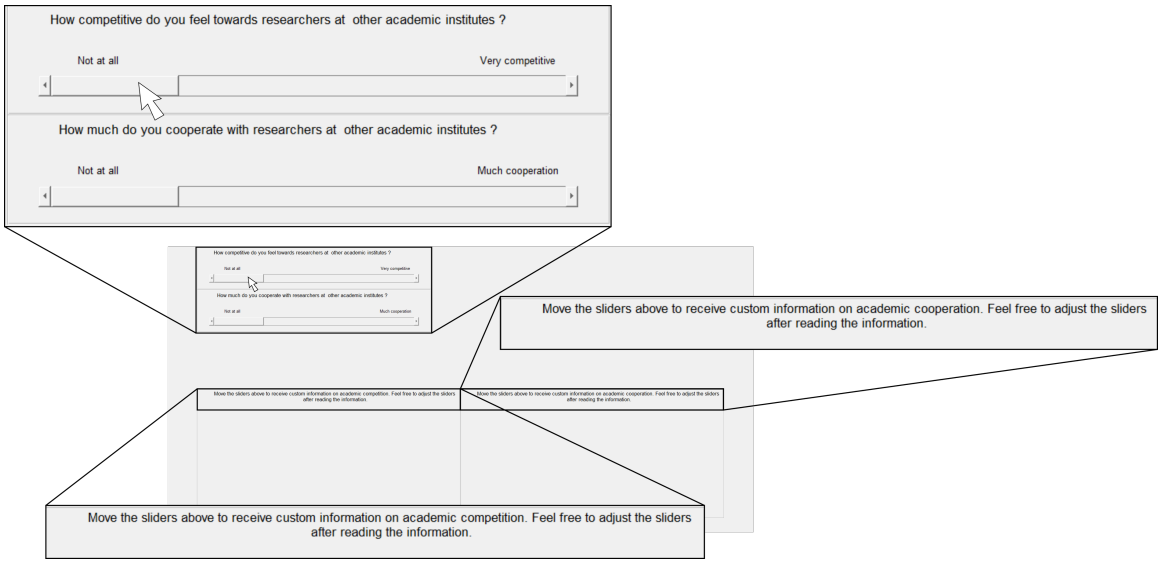

Figure 8.3: *The user can move the sliders to set their initial (unbiased) levels of competition and cooperation. The information boxes on the bottom of the user interface invite them to set their levels and explain that they can update these levels as they use the tool.*

Step 3: Visualise coopetition

After the user has set their ground levels, a plot appears with a point corresponding to the indicated levels of competition and cooperation. The main diagonal is shown on the plot as well, to visualise whether competition or cooperation is dominant.

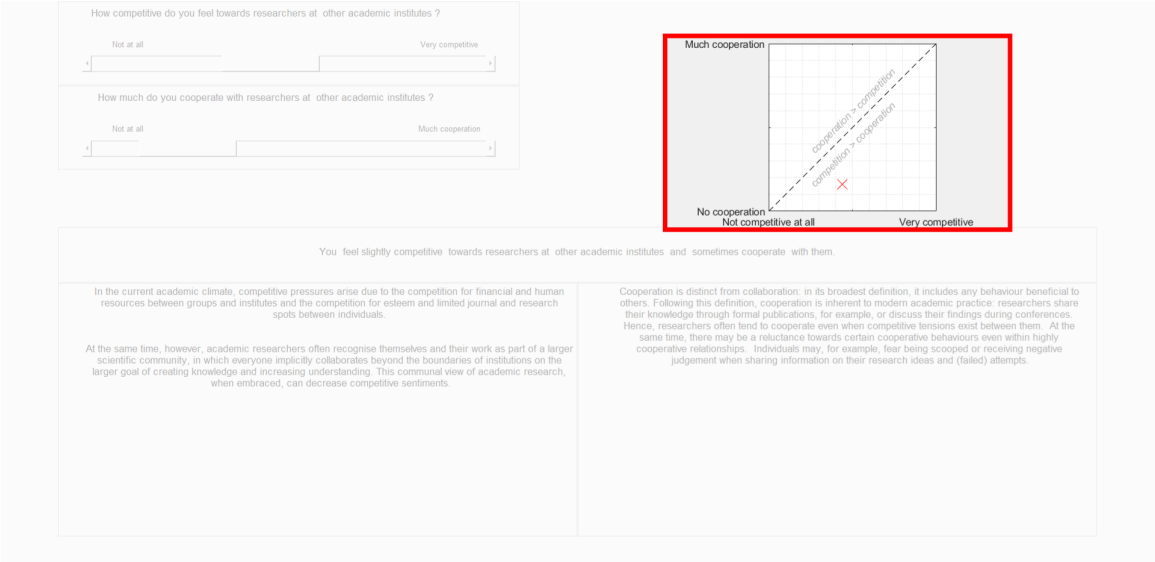

Figure 8.4: *After the user sets their competition and cooperation levels, a plot appears with cooperation on the vertical and competition on the horizontal axis. The red cross represents the user's set levels. The main diagonal separates the cooperation-dominant (top left) and the competition-dominant (bottom-right) regions of the graph.*

Step 4: Custom information.

Simultaneously with the plot, a third text box appears above the other two, describing the set levels of competition and cooperation. The original two boxes are filled with information on competition and cooperation relevant to the levels indicated by the user (see Figure 8.5). The information is based on

competition, cooperation, and coopetition theory and on the experiences shared by the survey respondents in the current study.

In the prototype, the competition levels are divided into three groups (not competitive, slightly competitive, very competitive), as are the cooperation levels (don't cooperate, sometimes cooperate, frequently cooperate). Hence, there are nine different information boxes for both competition and cooperation (one for each possible combination of competition and cooperation level; see Appendix D.2).

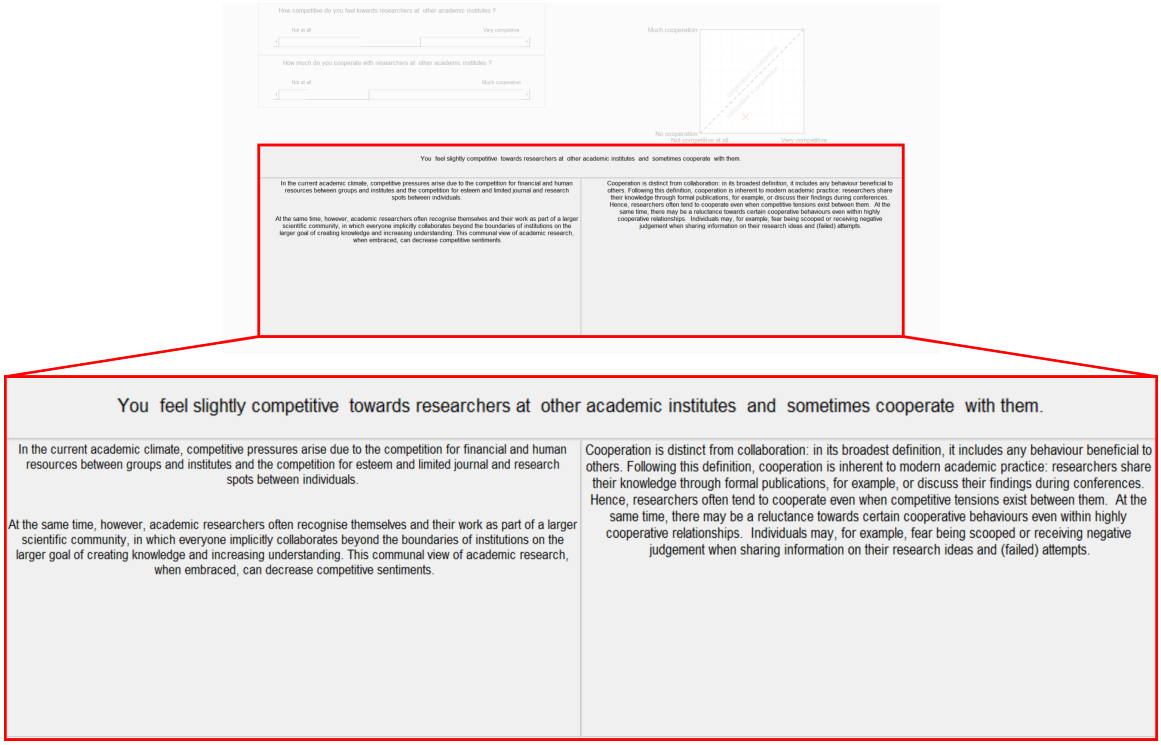

Figure 8.5: *After the user sets their competition and cooperation levels, information appears in three boxes: one with the set levels of competition and cooperation (top), one with information on competition (left) and one with information on cooperation (right). The information changes when the sliders are moved again. All nine possible pairs of text are included in Appendix D.2.*

Step 5 (optional): Adjust rating

After reading the information in the information boxes, the user may be inclined to change their initial ratings. They can do so by moving the sliders, upon which both the plot and the text in the information boxes will be updated. They can repeat this process until they are confident that their rating is representative of their true sentiments. This rating can then be shared (or exchanged) and discussed with colleagues, supervisors or managers.

8.4 Feedback sessions

To evaluate the GICCo prototype, two in-person, one-on-one feedback sessions were organised between different PhD researchers in microscopy-related fields, hereafter referred to as P1 and P2, and the head researcher. The sessions lasted for approximately thirty minutes. Both participant signed the informed consent form included in Appendix E.

To avoid bias, P1 and P2 were presented with the GICCo interface without further explanation. They were then observed as they navigated the tool. P1 used the tool as intended (see section 8.3). P2

appeared less confident and required affirmation that they were using GICCo correctly.

After P1 and P2 indicated that they were done using the tool, a short semi-structured interview was conducted. The prepared questions, divided into four sections, were intended to evaluate both the user experience and how well the GICCo prototype adhered to the main design criteria. As the interview was semi-structured, the questions were not asked with the exact phrasing presented below, nor in the exact order.

- Using GICCo
  - Did you find the interface intuitive?
    P1 answered this question affirmatively, confirming the observation that they found the interface intuitive. They did not fully understand whether the information in the boxes was general or in response to their specific competition and cooperation rating. P2 also found the tool easy to use, but did not immediately understand that they were supposed the read the text in the information boxes while adjusting the sliders, not just after giving a final rating.

  - Would you have liked an introduction?

    P1 did not find an introduction necessary while P2 did. P2 would have liked to understand the purpose of the tool beforehand. P2 was then explained the idea of requesting unbiased competition and cooperation ratings at initialisation to later demonstrate potential discrepancies between the user's own perception and scientific theory and experiences. They understood this idea, but still thought a quick introduction with some preparation on what to do would have been good. They believed this could be done without limiting the users' thoughts.

    Improvement: In the first version of the prototype, the information boxes were empty at initialisation. To make GICCo more self-explanatory, a short text was added to the information boxes at initialisation (see section 8.3). To avoid bias, this text did not include theory on the concepts of competition and cooperation, nor on the goal of GICCo.

  - Did you adjust your competition and/or cooperation rating?
    P1 stated that they increased their cooperation rating after reading the text, because the text made them realise that cooperation is more than just collaboration. P2 stated that they did not change their rating, but that the tool did make them think about competition and cooperation. They did not think about competition much anymore, but using GICCo made them contemplate where there could be competition in academia.

    Reflection: Both P1 and P2 interacted with the GICCo interface, in line with the "Interactive" criterion. Additionally, their answers reveal that the tool fulfils its purpose of inviting the users to contemplate what competition and cooperation mean to them and their work.

- Purpose of GICCo
  - What do you think the purpose of this tool is?
    P2 indicated that they experienced the tool as a type of psychological test: the user can find out their current situation, which group they belong to (he saw that there were nine possible "groups" of competition and cooperation scores), and what the benefits and potential improvements for each group are. They did not, however, understand what the purpose of this

"test" was. P1 could not guess the purpose of the tool either.

Reflection: To help users understand the purpose of GICCo without introducing bias, a concluding screen can be added to the GICCo interface in the future. After finalising their competition and cooperation ratings, the users are then directed to this screen, which contains an explanation on the purpose of the tool and a link to the current study.

- Would you use this tool?
  P1 would use the tool but did not currently feel the need to do so. They would find it useful and interesting to see the ratings of close colleagues as well as more distant peers at other institutes. They would like to see, for example, if researchers at other institutes cooperate more. P2 also found the tool useful and explained that it could make them aware that they might need to cooperate when they not currently cooperating. They added that the tool can make people think about cooperating before starting a cooperation or collaboration. These people might come to realise that they are too closed and using GICCo can make them aware of their (competitive) sentiments prior to a cooperation or collaboration, so that competitive issues do not arise unexpectedly during the actual interactions.

  Reflection: These answers fit the intended use of GICCo.

- Experience with GICCo
  - What did you like about the tool?
    P1 found it clear that the user is supposed to drag the sliders and they liked the plot. P2 also liked the plot as it helped them understand at which position they were. P2 thought the information text was really good.

  - What did you dislike about the tool?

    Reflection: This question was already answered by the responses to other questions.

- Improvements for GICCo
  - What can be improved in the tool design?

    P2 had not realised that they could drag the sliders. They would have liked ticks and text above the sliders to indicate what the different slider positions represent. Alternatively, they suggested replacing the sliders with Likert scales. Regarding the plot, P1 would have preferred a square grid and both P1 and P2 were confused about the diagonal line in the plot separating the competition-dominant and the cooperation-dominant regions of the graph. When asked, both agreed that it would be clear if the line was labelled. P2 added that a clear distinction between the nine different regions might be nice, for example by variably colouring the face of the graph. Regarding the text boxes, P1 noted that the similar appearance of the result box ("You feel ... competitive and ... cooperate") and the information boxes added to their confusion on whether the information provided was personalised or general. Lastly, P2 made the general comment that the user interface should be more polished in terms of appearance.

    Reflection: The sliders were maintained as the competition and cooperation levels are continuous

rather than discrete. No additional text was added above them to avoid clutter. The distinction in the plot between the nine different regions was not added, again because the competition and cooperation levels should be seen as continuous, even though the information in the boxes is presented in discrete groups. In general, as well as in response to the comment on the text boxes: aesthetic considerations, such as the fonts and colours, were not included when designing the GICCo prototype. Because these considerations affect the usability of the tool, as illustrated by the responses of P1 and P2 to the question above, they should be addressed in future versions of the tool.

Improvement: In the plot, the grid aspect ratio between the competition and the cooperation axis was set to one and the text "cooperation $>$ competition" was added above the main diagonal and "competition $>$ cooperation" below it.

– What can be improved in the tool's information content?
P1 found the phrasing of the information in the boxes too formal and thought that it would have been easier to read if it had been written in simpler language. P2 would have liked suggestions on how to improve with regard to competition and cooperation. They did stress that these suggestions should not be forceful. They also thought that, depending on the goal of using the tool, more text could be added to the information boxes.

Reflection: The information content is limited in the current prototype. When updating and extending this information in future versions, following further research in academic coopetition, the suggestions of the interviewees should be taken into account.

9. Conclusions and outlook

The current study has provided an initial exploration into the application of the concept of coopetition in the context of academia. A literature search was conducted first to acquire an understanding of the concept of coopetition and **extract the theories relevant to academic relationships (sub-RQ1)**. Of note, the relationship between competition and cooperation was recognised as being two-dimensional, allowing them to co-exist between the same parties. Additionally, the relevance of behavioural economics was stressed, as the theories in this field incorporate the effects of psychological, cognitive, and social factors that make individuals divert from rational expectations in their behaviour.

Based on these and related theories, an online survey was conducted to **assess academic researchers' experiences with professional competition and cooperation (sub-RQ2)**. The respondents mainly reported competitive sentiments towards other researchers at different academic institutes, providing the fear of being scooped in the competition for limited resources as the main reason. The numbers of respondents who felt that this competition affected their work positively versus negatively were approximately equal.

Sharing information was chosen as a representative example of academic cooperation. The reported motivations for sharing were the greater scientific good, the opportunity to receive feedback, and the chance to help others; apprehension towards sharing stemmed from competition, the fear of judgement, and quality concerns.

Notably, both the frequency of and the comfort with sharing were found to decrease with increasing peer distance, but competitive sentiments were only reported towards colleagues at other academic institutes. This suggests a two-dimensional relationship between the two concepts in academia as well.

Evidence was also found that the respondents understated their competitive sentiments, deliberately or due to cognitive bias because of the conventionally negative perception of competition. This finding provided the basis for answering **sub-RQ3 "How can academic researchers be assisted in navigating the tensions within and between professional competition and cooperation"**: a tool was designed to help academic researchers better understand their own competition and cooperation, as well as academic competition and cooperation in general. This interactive Guide for Introspection on Competition and Cooperation (GICCo) invites users to reflect on their own sentiments and provides them with personalised information, based on literature findings and empirical evidence from the current study.

Together, the three study elements address the **main RQ of how and why academic researchers combine competition and cooperation in their relationships with fellow researchers**. Competition was largely described by the survey respondents as being imposed on them through current funding and publication structures, yet they recognised both its positive and its negative influences on their work. There was a limited relationship between the respondents' resulting competitive sentiments and their cooperative behaviour, as measured by their sharing of research information: competition was only one element in the broad range of motivations the respondents provided for sharing or witholding information. The researchers' combination of competition and cooperation was therefore not a strict trade-off, but of a more ambiguous nature, with additional roles for elements like dedication to the greater scientific good. (Subconscious) biases were also suggested to play a role in this: a discrepancy was indicated between

researchers' perceived and actual competitive sentiments, confounding both their "how" and their "why" of combining competition and cooperation.

These results can now serve as a guide for further work on this topic. To create a more comprehensive overview of existing work on (academic) coopetition, both explicit and implicit, it is recommended to first perform a systematic review. Subsequently, the survey can be adapted to and repeated with a larger group of respondents to verify the current study's findings on academic work motivation, competition, and cooperation. In such a follow-up study, the scope can also be extended to cover an academic equivalent of vertical coopetition: with a large and diverse group of participants, the relationships between researchers at different points in the fundamental-to-applied research pipeline can be assessed and compared to vertical industry coopetition, as well as to the horizontal relationships between researchers with different group affiliations. As the last step in, or rather a supplement to, the academic pipeline, commercial researchers can be included to compare the effect of an inherently competitive environment, the industry, on individual sentiments on interpersonal relationships, to the effect of a historically cooperative environment, academia.

As the field of academic coopetition research matures, additional study elements can be aimed at explaining rather than exploring the topic. A prime example is the one-on-one interview, which allow researchers to expand on emerging points of interest and allow participants to elaborate on their answers.

The new insights from the literature review and subsequent empirical methodologies can then be used to continue building and improving GICCo. It is important to remember, however, that GICCo will never be "finished": it is designed to fit the contemporary academic climate and, as such, should continuously evolve as this climate evolves.

10. Study limitations

To fit the scope of the current study, a literature search was conducted as opposed to a systematic literature review. While sufficient for the construction of a theoretical framework on which to built the subsequent empirical study, the presented theory is therefore far from exhaustive. In particular, the choice was made to focus the literature search on explicit coopetition studies. The inclusion of work on competition and cooperation separately, both in general an in the context of academia, was limited, as was the inclusion of implicit coopetition studies.

The subsequent survey was designed to be exploratory rather than explanatory, to serve as an initial exploration into the application of coopetition theory on academic settings. Exploratory studies, however, benefit from large participant numbers, and the different sections of the survey were completed by only 20 to 43 respondents. It was therefore not possible to separate the respondents into sufficiently large groups based on their fields of expertise, so the effect of research focus on academic coopetition could not be assessed, nor could horizontal and vertical relationships be distinguished and studied.

Additionally, the limited sample size meant that the analytical results were rarely statistically significant. Their implications, as described in Chapter 7, should therefore be taken more as suggestions for further research than as absolute conclusions.

Due to the self-report measures, the results may have also been subject to common method biases (Podsakoff et al., 2003). These were not controlled for in the current study, as their effect is expected to be inferior to the effect of the small sample size, but should be addressed in any follow-up research with larger samples.

Furthermore, because the survey respondents self-reported both their work motivations and their competitive sentiments, with limited room to elaborate, no distinction could be made between their true behaviour and feelings on one side and how they perceive or wish to perceive themselves on the other. It is therefore possible that the reported levels of competition are more reflective of what the respondents deem appropriate than of what they actually experience. This bias partly motivated the design of GICCo, but should not be ignored in follow-up studies. As work on the topic progresses from exploratory to explanatory in nature, it is recommended to supplement or replace the online survey with methods that allow for additional questioning on potential biases and contradictions, such as one-on-one interviews.

As the literature search and survey results lay at the basis of the tool design, the limitations described above translate to the current prototype. The subsequent step from evaluation-stage to the communication-stage of the design process (see Figure 8.1) remains valuable, but a continuation of the design process through addition of a feedback loop from the communication-stage to both the generation- and the evaluation-stage may be worthwhile.

11. Personal reflection

I think I went through the typical thesis process: come up with a research idea, realise that executing it will take between five and twenty years, then condense it to something feasible while maintaining the essence of the original inspiration. This process typically requires a choice between two options: limit the number of elements in the study to be able to expand on the remaining elements, or maintain all elements but limit how thoroughly each of them is executed. I usually prefer the first alternative, but the CDI thesis format pushed me to the latter as it included a strict inclusion requirement of different elements. My structured literature review therefore became a literature search, that I supplemented with a brief online survey, the results of which I used to develop an interactive tool. Especially the last step, to the development of the tool, was uncomfortable: I did not feel that the knowledge I had generated within the limited scope of my project was sufficient to base a valuable tool on. As such, developing the tool felt more like a secondary school project than a part of a university assignment, much less a genuine contribution of science.

Regarding my general experience with CDI and doing a CDI thesis project, my double degree has allowed be to compare at least two university programmes and draw the conclusion that CDI was by far the most rigid - and, in my experience, the most reluctant to admit to this rigidity. The teachers continuously urged us to think outside the box, but failed to mention that we should subsequently move into a new box of their design. This contradiction fed into my existing frustration stemming from the growing realisation that social scientific work is not the direction for me. I will admit that my existing prejudices towards social sciences did not help. Furthermore, I do not mean to attack the CDI staff personally: while I did not agree with their methods, I do not doubt their integrity nor their dedication to the programme and its students.

To end on a positive note, and to explain why I did finish the programme if my view on its contents was so negative, I want to reflect on the CDI student community. For me, this is where the main value of the double degree lay. My peers' wide range in backgrounds, both educational and personal, brought me insights into different perspectives on technology and innovation. Driven by both the CDI staff and the students themselves, the CDI student body became a community in which knowledge and ideas were freely exchanged. Cliché as it may sound, I felt more welcome here than anywhere else in my academic career, and that is at least as important to me as the educational contents concerned.

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A. Survey respondents' research fields

The survey respondents' answers to the questions "What is your current research field?" are listed below in alphabetical order. Groupings are made for legibility rather than definitive categorisation. If a research field was given by multiple respondents, this is indicated with the number between brackets. Some respondents gave multiple answers.

- Biology
  - Biology [1]
  - Cell biology
    - Cell biology [2]
    - Cancer cell biology [1]
    - Cell migration [1]
  - Microbiology [1]
  - Molecular biology [1]
  - Plant auxin biology [1]
  - Structural biology [2]
- Biomedicine
  - Biomedicine [1]
  - Biomedical microscopy [2]
- Biophysics
  - Biophysics [3]
  - Single-cell biophysics [1]
- Biomolecular ultra-sound [1]
- Genetics
  - Genetics [1]
  - Gene transcription regulation [1]
- Geothermal Resources [1]
- Image analysis [1]
- Image and signal processing [1]
- Induced pluripotent stem cells (iPSC)[1]
- Life Sciences [1]
- Imaging
  - Microscopy
    - Cryo Electron Microscopy [1]
    - Electron Microscopy [2]
    - Microscopy [4]
    - Optical diffraction microscopy [1]
    - Optical microscopy [1]
    - Quantitative microscopy [1]
    - Super-resolution microscopy [2]
    - Voltage nanoscopy [1]
  - Optical tomography [1]

  - Ultrasound imaging (bio-molecular ultrasound) [1]
- Muscle ageing [1]
- Neuroscience
  - Neurodegenerative disorders on iPSC-derived cell models [1]
  - Neuroimmunology [1]
  - Neuroinflammation [1]
  - Neuroscience [6]
  - Synapse biology [1]
- Optogenetics [1]
- Soft matter physics [1]

B. Opening statement

Opening statement "Competition and cooperation in academia"

You are being invited to participate in a research study on **competition and cooperation in academia**. This study is being done by Enya Berrevoets for her Communication Design for Innovation (CDI, formerly Science Communication) **Master's thesis** at the TU Delft. The purpose of this research study is to learn how academic researchers in microscopy-related fields navigate the social aspects of academia and will take you approximately **5-10 minutes** to complete.

The data will be used for the thesis and any publications that may follow from it. We will be asking you about your experiences with competition and cooperation in academia. Please note that **cooperation is not the same as collaboration**: collaboration is a relationship in which different people work together on the same, or closely related, projects, whereas cooperation is a behaviour that can occur within different relationships, competitive or collaborative.

As with any online activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by keeping the survey fully anonymous. Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any questions you do not feel comfortable answering.

Contact information If you have any questions or concerns about this survey, do not hesitate to contact the researchers.
Enya Berrevoets (head researcher): [email address head researcher] Éva Kalmar (supervisor): [email address supervising researcher]

C. Survey

TU Delft

Introduction

Q146. You are being invited to participate in a research study on **competition and cooperation in academia**. This study is being done by Enya Berrevoets for her Communication Design for Innovation (CDI, formerly Science Communication) **Master's thesis** at the TU Delft.

The purpose of this research study is to learn how academic researchers in microscopy-related fields navigate the social aspects of academia and will take you approximately **5-10 minutes** to complete.

The data will be used for the thesis and any publications that may follow from it. We will be asking you about your experiences with competition and cooperation in academia. Please note that cooperation is not the same as collaboration: collaboration is a relationship in which different people work together on the same, or closely related, projects, whereas cooperation is a behaviour that can occur within different relationships, competitive or collaborative.

As with any online activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by keeping the survey **fully anonymous**. Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any questions you do not feel comfortable answering.

Contact information
If you have any questions or concerns about this survey, do not hesitate to contact the researchers at:
Enya Berrevoets (head researcher): **e.s.berrevoets@student.tudelft.nl**
Éva Kalmar (supervisor): **e.kalmar-1@tudelft.nl**

- ○ I understand and want to proceed to the survey

Academic career

Q7.1. Academic career

The following questions relate to your academic career. Your answers are anonymous and will not be connected to answers in the rest of the survey, but you are free to skip any questions you do not feel comfortable answering.

Q1.1. At which institute (e.g., which university) are you currently employed?

Q1.2. What is your current academic rank?

- ○ PhD student
- ○ Postdoctoral researcher
- ○ Assistant professor
- ○ Associate professor
- ○ Full professor
- ○ Other:

Q1.3. How many years have you been conducting academic research for?

Q1.4. What is your current research field?

Q1.5. Have you been a professional researcher in other field(s)?

- ○ Yes
- ○ No

Q1.6. In which other field(s) and for which institute(s) have you been a professional researcher?

Q1.7. What are your motivations for doing academic research?

Please move all sliders, also if you want to keep them in the middle

	Does not motivate you 1	2	Slightly motivates you 3	4	Strongly motivates you 5
It's a good way to make money					
It's fun					
My personal goals/values match with those in (my branch of) academia					

	Does not motivate you 1	2	Slightly motivates you 3	4	Strongly motivates you 5	
It challenges me to use my skills and talents						☐
It is a widely respected and appreciated career						☐
I want to gain experience/qualifications before moving to a different profession						☐
Other: ☐						☐

Peer contact

Q7.3. Peer contact

The following questions relate to the frequency and the nature of your interactions with other researchers.

Q2.1. **How often** do you interact directly (in-person or digitally) with researchers at...

	Never	Yearly	Several times a year	Monthly	Weekly	N/A
...your own research group?	○	○	○	○	○	○
...other groups at your department?	○	○	○	○	○	○
...other departments at your institute?	○	○	○	○	○	○
...other academic institutes?	○	○	○	○	○	○
...non-academic institutes?	○	○	○	○	○	○

Q2.2. Which interactions do you have **multiple times a year** with researchers at...

Select all that apply

	Casual meetings	Formal meetings	Networking events (e.g., conferences)	Direct messaging (e.g., email)	Reading their publications	Social media	Other:
» ...your own research group?	☐	☐	☐	☐	☐	☐	
» ...other groups at your department?	☐	☐	☐	☐	☐	☐	
» ...other departments at your institute?	☐	☐	☐	☐	☐	☐	
» ...other academic institutes?	☐	☐	☐	☐	☐	☐	
» ...non-academic institutes?	☐	☐	☐	☐	☐	☐	

Q2.3. How often do you **collaborate on projects** with researchers at...

	Never	Rarely	Regularly	Frequently	N/A
» ...your own research group?	○	○	○	○	○
» ...other groups at your department?	○	○	○	○	○
» ...other departments at your institute?	○	○	○	○	○
» ...other academic institutes?	○	○	○	○	○
» ...non-academic institutes?	○	○	○	○	○

Q2.4. **How often** do you interact directly (in-person or digitally) with researchers in the field of...

	Never	Yearly	Several times a year	Monthly	Weekly	N/A
...optics and imaging physics?	○	○	○	○	○	○
...computational microscopy?	○	○	○	○	○	○
...microscope engineering?	○	○	○	○	○	○
...cellular and micro-/nanobiology?	○	○	○	○	○	○
...other:	○	○	○	○	○	○

Q2.5. Which interactions do you have **multiple times a year** with researchers in the field of...

Select all that apply

	Casual meetings	Formal meetings	Networking events (e.g., conferences)	Direct messaging (e.g., email)	Reading their publications	Social media
» ...optics and imaging physics?	☐	☐	☐	☐	☐	☐
» ...computational microscopy?	☐	☐	☐	☐	☐	☐
» ...microscope engineering?	☐	☐	☐	☐	☐	☐
» ...cellular and micro-/nanobiology?	☐	☐	☐	☐	☐	☐
» ...other:	☐	☐	☐	☐	☐	☐

Q2.6. How often do you **collaborate on projects** with researchers in the field of...

	Never	Rarely	Regularly	Frequently	N/A
» ...optics and imaging physics?	○	○	○	○	○

	Never	Rarely	Regularly	Frequently	N/A
» ...computational microscopy?	○	○	○	○	○
» ...microscope engineering?	○	○	○	○	○
» ...cellular and micro-/nanobiology?	○	○	○	○	○
» ...other:	○	○	○	○	○

Competition

Q7.4. Academic competition

The following questions relate to how you experience academic competition and how this affects your research. Competition should be interpreted broadly, to include not only formal competition, e.g. for grants, but also less visible types, like competition for research spots and competitive sentiments between close colleagues.

Q3.1. Do you feel competitive towards researchers at...

	Not at all	Slightly competitive	Competitive	Very competitive	N/A
...your own research group?	○	○	○	○	○
...other research groups at your department?	○	○	○	○	○
...other departments at your institute?	○	○	○	○	○
...other academic institutes?	○	○	○	○	○
...non-academic (e.g., commercial) institutes?	○	○	○	○	○

Q3.2. Why do you feel competitive towards the aforementioned researchers?

Q3.3. How do your competitive feelings affect your research?

Q3.4. Do you feel competitive towards researchers in the field of...

	Not at all	Slightly competitive	Competitive	Very competitive
...optics and imaging physics?	○	○	○	○
...computational microscopy?	○	○	○	○
...microscope engineering?	○	○	○	○
...cellular and micro-/nanobiology?	○	○	○	○
...other:	○	○	○	○

Q3.5. Why do you feel competitive towards the aforementioned researchers?

Q3.6. How do your competitive feelings affect your research?

Sharing unpublished information

Q7.5. Sharing unpublished information

The following questions relate to how you handle different types of unpublished information, i.e., information that is **not included in formal scientific papers**.

Q3.1. How often do you share your **research ideas** with researchers at...

	Never	Yearly	Several times a year	Monthly	Weekly	N/A
...your own research group?	○	○	○	○	○	○
...other groups at your department?	○	○	○	○	○	○
...other departments at your institute?	○	○	○	○	○	○
...other academic institutes?	○	○	○	○	○	○
...non-academic institutes?	○	○	○	○	○	○

Q3.2. Do or would you feel comfortable sharing your **research ideas** with researchers at...

Please move all sliders, also if you want to keep them at 1

	Very uncomfortable		Neutral		Very comfortable
	1	2	3	4	
...your own research group?	»				
...other groups at your department?	»				
...other departments at your institute?	»				
...other academic institutes?	»				
...non-academic institutes?	»				

Q3.3. Why do you feel this way about sharing your **research ideas**?

Q3.4. How often do you share your **unsuccessful attempts** with researchers at...

	Never	Yearly	Several times a year	Monthly	Weekly	N/A
...your own research group?	○	○	○	○	○	○
...other groups at your department?	○	○	○	○	○	○
...other departments at your institute?	○	○	○	○	○	○
...other academic institutes?	○	○	○	○	○	○
...non-academic institutes?	○	○	○	○	○	○

Q3.5. Do or would you feel comfortable sharing details on your **unsuccessful attempts** with researchers at...

Please move all sliders, also if you want to keep them at 1

	Very uncomfortable		Neutral		Very comfortable
	1	2	3	4	
...your own research group?					
...other groups at your department?					
...other departments at your institute?					
...other academic institutes?					
...non-academic institutes?					

Q3.6. Why do you feel this way about sharing details on your **unsuccessful attempts**?

Q3.7. How often do you share your **preliminary results** with researchers at...

	Never	Yearly	Several times a year	Monthly	Weekly	N/A
...your own research group?	○	○	○	○	○	○
...other groups at your department?	○	○	○	○	○	○
...other departments at your institute?	○	○	○	○	○	○
...other academic institutes?	○	○	○	○	○	○
...non-academic institutes?	○	○	○	○	○	○

Q3.8. Do or would you feel comfortable sharing your **preliminary results** with researchers at...

Please move all sliders, also if you want to keep them at 1

	Very uncomfortable 1	2	Neutral 3	Very comfortable 4
...your own research group?				
...other groups at your department?				
...other departments at your institute?				
...other academic institutes?				

	Very uncomfortable		Neutral		Very comfortable
	1	2	3	4	
» ...non-academic institutes?					

Q3.9. Why do you feel this way about sharing your **preliminary results**?

Q3.10. How often do you share your **unpublished data** with researchers at...

	Never	Yearly	Several times a year	Monthly	Weekly	N/A
» ...your own research group?	○	○	○	○	○	○
» ...other groups at your department?	○	○	○	○	○	○
» ...other departments at your institute?	○	○	○	○	○	○
» ...other academic institutes?	○	○	○	○	○	○
» ...non-academic institutes?	○	○	○	○	○	○

Q3.11. Do or would you feel comfortable sharing your **unpublished data** with researchers at...

Please move all sliders, also if you want to keep them at 1

	Very uncomfortable		Neutral		Very comfortable
	1	2	3	4	
» ...your own research group?					
» ...other groups at your department?					

	Very uncomfortable 1	2	Neutral 3	Very comfortable 4
» ...other departments at your institute?				
» ...other academic institutes?				
» ...non-academic institutes?				

Q3.12. Why do you feel this way about sharing your **unpublished data**?

Q3.13. How often do you share your **pre-prints** with researchers at...

	Never	Yearly	Several times a year	Monthly	Weekly	N/A
» ...your own research group?	○	○	○	○	○	○
» ...other groups at your department?	○	○	○	○	○	○
» ...other departments at your institute?	○	○	○	○	○	○
» ...other academic institutes?	○	○	○	○	○	○
» ...non-academic institutes?	○	○	○	○	○	○

Q3.14. Do or would you feel comfortable sharing your **pre-prints** with researchers at...

Please move all sliders, also if you want to keep them at 1

	Very uncomfortable 1	2	Neutral 3	Very comfortable 4
...your own research group?	»			
...other research groups at your department?	»			
...other departments at your institute?	»			
...other academic institutes?	»			
...non-academic (e.g., commercial) institutes?	»			

Q3.15. Why do you feel this way about sharing your **pre-prints**?

Q3.16. How often do you share your **any of your unpublished information** with researchers in the field of...

	Never	Yearly	Several times a year	Monthly	Weekly	N/A
...optics and imaging physics?	○	○	○	○	○	○
...computational microscopy?	○	○	○	○	○	○
...microscope engineering?	○	○	○	○	○	○
...cellular and micro-/nanobiology?	○	○	○	○	○	○

	Never	Yearly	Several times a year	Monthly	Weekly	N/A
...other:						

Q3.17. Do or would you feel comfortable sharing your unpublished information with researchers in the field of...

Please move all sliders, also if you want to keep them at 1

	Very uncomfortable		Neutral		Very comfortable
	1	2	3	4	
» ...optics and imaging physics?					
» ...computational microscopy?					
» ...microscope engineering?					
» ...cellular and micro-/nanobiology?					
» ...other:					

Q3.18. Why do you feel this way about sharing your unpublished information with researchers in different fields?

Q3.19. What other unpublished research information do you share, with whom, and how?

D.1 MATLAB code

```
\% Main.m

close all
selectGroup

%%
function [group] = selectGroup
screen = get(0,'screensize');
fig = figure;
set(fig,'Position',[round(screen(3)/12) round(screen(4)/3)...
round(screen(3)/1.2) round(screen(4)/3)])
qgroup = uicontrol(fig,'Style','text','Units','normalized','Position',...
[0,0.3,0.5,0.2],...
                'String','Investigate your relationship with researchers at',...
                'FontSize',12);


c = uicontrol(fig,'Style','popupmenu',...
    'String',{"other academic institutes"},...
    'FontSize',12,'Units','normalized','Position',[0.1,0.15,0.3,0.1]);
c.Callback = @selection;
group = cellstr(c.String{c.Value});
save('GroupSelection.mat', 'group');

    function [group] = selection(src,event)
        val = c.Value;
        str = c.String;
        group = cellstr(str{val});
        save('GroupSelection.mat', 'group');
    end

sbutton = uicontrol(fig,'Style','pushbutton','String','Start','FontSize',12,...
    'Units','normalized','Position',[0.45,0.15,0.1,0.1]);
sbutton.Callback = {@start};


    function start(src,event)

        close
        load GroupSelection.mat
```

```
screen = get(0,'screensize');
vals = 0:2;
fig = figure;
set(fig,'Position',[0 0 screen(3) screen(4)*11/12])

pcomp = uipanel(fig,'Position',[0.05 0.85 0.40 0.15]);

scomp = uicontrol(pcomp,'Style', 'Slider', ...
          'SliderStep', [1/max(vals),1/3], ...
          'Min', min(vals), 'Max', max(vals), ...
          'Units','normalized','Position',[0.05,0.15,0.9,0.2], ...
          "String","How competitive",...
          "Callback",@ChangeComp);

ValComp = scomp.Value;
save('ValComp.mat','ValComp')

qcomp = uicontrol(pcomp,'Style','text','Units','normalized','Position',...
[0.05,0.6,0.8,0.35],...
                'String',strjoin(['How competitive do you feel towards...
                researchers at ' group '?']),...
                'FontSize',10);
mincomp = uicontrol(pcomp,'Style','text','Units','normalized','Position',...
[0.05,0.35,0.2,0.2], ...
                'String','Not at all');
maxcomp = uicontrol(pcomp,'Style','text','Units','normalized','Position',...
[0.7,0.35,0.3,0.2],...
                'String','Very competitive');

initComp = "Move the sliders above to receive custom information on ...
academic competition. Feel free to adjust the sliders ...
after reading the information.";
initCoop = "Move the sliders above to receive custom information on ...
academic cooperation. Feel free to adjust the sliders ...
after reading the information.";
ppcomp = uipanel(fig,'Position',[0.05 0.05 0.45 0.45]);
uicontrol(ppcomp,'Style','text','Units','normalized','Position',...
[0.05,0.05,0.95,0.95],...
        'String',initComp,'FontSize',10);

% ppcomp.Scrollable = "on";

ppcoop = uipanel(fig,'Position',[0.5 0.05 0.45 0.45]);
uicontrol(ppcoop,'Style','text','Units','normalized','Position',...
[0.05,0.05,0.95,0.95],...
'String',initCoop,'FontSize',10);
```

```
function ChangeComp(src,event)
    ValComp = scomp.Value;
    save('ValComp.mat','ValComp')
    load ValCoop.mat
    subplot(5,2,[2 4])
    plot(vals,vals,'--black'); hold on
    daspect([1 1 1])
    text(max(vals)-1,max(vals)-0.8,'cooperation > competition',...
        'HorizontalAlignment','center','Rotation',45,'FontAngle',...
        'italic','Color',[0.7 0.7 0.7])
    text(max(vals)-1,max(vals)-1.2,'competition > cooperation',...
        'HorizontalAlignment','center','Rotation',45,'FontAngle',...
        'italic','Color',[0.7 0.7 0.7])
    scatter(ValComp,ValCoop,200,'red','x'); hold off
    xlim([0 max(vals)]); xticks(0:max(vals))
    ylim([0 max(vals)]); yticks(0:max(vals))
    xticklabels(["Not competitive at all" ""  "Very competitive"])
    xtickangle(0)
    yticklabels(["No cooperation" ""  "Much cooperation"])
    grid minor
    set(gca,'FontSize',10)
    % mincomp.Visible = "off";
    textout(group,ValComp,ValCoop,fig,vals)

end

pcoop = uipanel(fig,'Position',[0.05 0.7 0.40 0.15]);
scoop = uicontrol(pcoop,'Style', 'Slider', ...
          'SliderStep', [1/max(vals),1/3], ...
          "Position",[20 20 400 20], ...
          'Min', min(vals), 'Max', max(vals), ...
          'Units','normalized','Position',[0.05,0.15,0.9,0.2], ...
          "String","How competitive",...
          'Callback',@ChangeCoop);

ValCoop = scoop.Value;
save('ValCoop.mat','ValCoop')

qcoop = uicontrol(pcoop,'Style','text','Units','normalized','Position',..
[0.05,0.6,0.8,0.35],...
                'String',strjoin(['How much do you cooperate with ...
                researchers at ' group '?']),...
                'FontSize',10);
mincoop = uicontrol(pcoop,'Style','text','Units','normalized','Position',
[0.05,0.35,0.2,0.2],...
                'String','Not at all');
```

```
        maxcoop = uicontrol(pcoop,'Style','text','Units','normalized','Position',...
        [0.7,0.35,0.3,0.2],...
                        'String','Much cooperation',...
                    'Callback',@ChangeCoop);


        function ChangeCoop(src,event)
            ValCoop = scoop.Value;
            save('ValCoop.mat','ValCoop')
            load ValComp.mat
            subplot(5,2,[2 4])
            plot(vals,vals,'--black');hold on
            daspect([1 1 1])
            text(max(vals)-1,max(vals)-0.8,'cooperation > competition',...
                'HorizontalAlignment','center','Rotation',45,'FontAngle',...
                'italic','Color',[0.7 0.7 0.7])
            text(max(vals)-1,max(vals)-1.2,'competition > cooperation',...
                'HorizontalAlignment','center','Rotation',45,'FontAngle',...
                'italic','Color',[0.7 0.7 0.7])
            scatter(ValComp,ValCoop,200,'red','x'); hold off
            xlim([0 max(vals)]); xticks(0:max(vals))
            ylim([0 max(vals)]); yticks(0:max(vals))
            xticklabels(["Not competitive at all" "" "Very competitive"])
            xtickangle(0)
            yticklabels(["No cooperation" "" "Much cooperation"])
            grid minor
            set(gca,'FontSize',10)
            textout(group,ValComp,ValCoop,fig,vals)
        end

    end

end

\%%%%%%%%%%%%%%%%%%%%

\% textout.m

function textout = textout(group, vcomp, vcoop,fig, vals)

tcomp = ["do not feel competitive", "feel slightly competitive",...
"feel very competitive"];
tcoop = ["do not cooperate","sometimes cooperate","frequently cooperate"];

if vcomp < 0.1
    vcomp = 1;
elseif vcomp <=max(vals)/2
```

```
    vcomp = 2;
else
    vcomp=3;
end

if vcoop<0.1
    vcoop = 1;

    if vcomp == 1
        compcoop=1;
    elseif vcomp==2
        compcoop=2;
    else compcoop=3;
    end

elseif vcoop <=max(vals)/2
    vcoop = 2;

    if vcomp == 1
        compcoop=4;
    elseif vcomp==2
        compcoop=5;
    else compcoop=6;
    end

else
    vcoop=3;

    if vcomp == 1
        compcoop=7;
    elseif vcomp==2
        compcoop=8;
    else compcoop=9;
    end

end

pp = uipanel(fig,'Position',[0.05 0.50 0.9 0.10]);
Text = strjoin(['You ' tcomp(vcomp) ' towards researchers at ' group ' and ' ...
tcoop(vcoop) ' with them.']);
uicontrol(pp,'Style','text','Units','normalized','Position',[0.05,0.3,0.9,0.4],...
        'String',Text,'FontSize',10);

TextComp = strjoin(['Information on competition if users ' tcomp(vcomp) ...
'towards researchers at ' group]);
TextCoop = strjoin(['Information on cooperation if users ' tcoop(vcoop) ...
'with researchers at ' group]);
```

```
[TextComp, TextCoop] = TextCompCoop(group,compcoop,TextComp, TextCoop);


ppcomp = uipanel(fig,'Position',[0.05 0.05 0.45 0.45]);
uicontrol(ppcomp,'Style','text','Units','normalized','Position',...
[0.05,0.05,0.95,0.95],...
        'String',TextComp,'FontSize',10);

ppcoop = uipanel(fig,'Position',[0.5 0.05 0.45 0.45]);
uicontrol(ppcoop,'Style','text','Units','normalized','Position',...
[0.05,0.05,0.95,0.95],...
        'String',TextCoop,'FontSize',10);

end

\%%%%%%%%%%%%%%%%%%%%%

\% TextCompCoop.m

function [tComp, tCoop] = TextCompCoop(group,compcoop, tComp,tCoop)


if group =="other academic institutes"

    if compcoop == 1
    % No competition, no cooperation

    tComp = ["In the current academic climate, different academic groups and institu
    tCoop = ["Cooperation is distinct from collaboration: in its broadest definition

    elseif compcoop == 2
    % Slight competition, no cooperation

    tComp = ["In the current academic climate, competitive pressures arise due to th
    tCoop = ["Cooperation is distinct from collaboration: in its broadest definition

    elseif compcoop == 3
    % High competition, no cooperation

    tComp = ["The modern academic climate is highly competitive due to the limited f
    tCoop = ["Cooperation is distinct from collaboration: in its broadest definition

    elseif compcoop == 4
    % No competition, slight cooperation

    tComp = ["The typical examples of competition in academic research are the compe
    tCoop = ["Cooperation is distinct from collaboration: in its broadest definition
```

```
    elseif compcoop == 5
    % Slight competition, slight cooperation

    tComp = ["In the current academic climate, competitive pressures arise due to
    tCoop = ["Cooperation is distinct from collaboration: in its broadest definit

    elseif compcoop == 6
    % High competition, slight cooperation

    tComp = ["The modern academic climate is highly competitive due to the limite
    tCoop = ["Cooperation is distinct from collaboration: in its broadest definit

    elseif compcoop == 7
    % No competition, high cooperation

    tComp = ["The typical examples of competition in academic research are the co
    tCoop = ["Cooperation is distinct from collaboration: in its broadest definit

    elseif compcoop == 8
    % Slight competition, high cooperation

    tComp = ["In the current academic climate, competitive pressures arise due to
    tCoop = ["Cooperation is distinct from collaboration: in its broadest definit

    elseif compcoop == 9
    % High competition, high cooperation

    tComp = ["The modern academic climate is highly competitive due to the limite
    tCoop = ["Cooperation is distinct from collaboration: in its broadest definit

    end

end

end
```

D.2 Information boxes

No competition, no cooperation

Competition

In the current academic climate, different academic groups and institutes explicitly compete for limited financial and human resources. This competitive pressure can be internalised by individual researchers, who then feel competitive on behalf of the institute, department,

or group they are affiliated with.

More implicit competition arises through the "publish or perish" system. Researchers reported apprehension towards sharing their findings out of fear of others scooping their ideas and publishing sooner.

On a personal level, some researchers have shared feeling competitive towards others when they feel their skills and achievements are being compared. This competition can also become explicit when interviewing for limited research spots.

Many researchers feel motivated by competitive pressure and indicate that it pushes them to optimise their research and their skills. Some, however, feel rushed by it and indicate it as a source of stress.

Cooperation

Cooperation is distinct from collaboration: in its broadest definition, it includes any behaviour beneficial to others. Following this definition, cooperation is inherent to modern academic practice: researchers share their knowledge through formal publications, for example, or discuss their findings during conferences. Hence, researchers often tend to cooperate even when they have no explicit relationship.

Researchers can also be motivated, intrinsically or by their supervisors or managers, to extend their cooperation beyond the inherent cooperative actions. Cooperation is a good way of establishing a positive relationship and building a professional network, and it may be reciprocated in the future. A direct benefit reported by researchers, besides the pleasure of helping others, is the feedback that can be obtained when sharing ideas and experiences.

No competition, slight cooperation

Competition

The typical examples of competition in academic research are the competition for financial and human resources between groups and institutes and the competition for limited journal and research spots between individuals.

Competition can also arise, however, between cooperating or even collaborating researchers: cooperation does not exclude competition and vice versa. Researchers can, for example, cooperate in one sense, or on one specific project, but compete in other senses. Furthermore, (implicit) competition can exist within cooperative relationships, for example when the individuals feel that their skills and achievements are being compared.

Many researchers feel motivated by competition and indicate that it pushes them to optimise their research and their skills. Some, however, feel rushed by it and indicate it as a source of stress.

Cooperation

Cooperation is distinct from collaboration: in its broadest definition, it includes any behaviour beneficial to others. Following this definition, cooperation is inherent to modern

academic practice: researchers share their knowledge through formal publications, for example, or discuss their findings during conferences. Hence, researchers often tend to cooperate even when they have no explicit relationship.

At the same time, there may be a reluctance towards certain cooperative behaviours even in the absence of competition. Individuals may, for example, fear being scooped or receiving negative judgement when sharing information on their research ideas and (failed) attempts.

No competition, high cooperation

Competition

The typical examples of competition in academic research are the competition for financial and human resources between groups and institutes and the competition for limited journal and research spots between individuals.

Competition can also arise, however, between cooperating or even collaborating researchers: cooperation does not exclude competition and vice versa. Researchers can, for example, cooperate in one sense, or on one specific project, but compete in other senses. Furthermore, (implicit) competition can exist within cooperative relationships, for example when the individuals feel that their skills and achievements are being compared.

Many researchers feel motivated by competition and indicate that it pushes them to optimise their research and their skills. Some, however, feel rushed by it and indicate it as a source of stress.

Cooperation

Cooperation is distinct from collaboration: in its broadest definition, it includes any behaviour beneficial to someone else, such as sharing research ideas and experiences. Even within collaborations, or cooperative relationships in general, there may then be cooperative behaviours that the individuals involved are not comfortable with. While the fear of having one's ideas taken is typically limited in these cases, early career researchers in particular have reported a fear of receiving negative judgement when sharing their ideas and experiences, especially experiences of failed experimental attempts.

Slight competition, no cooperation

Competition

In the current academic climate, competitive pressures arise due to the competition for financial and human resources between groups and institutes and the competition for esteem and limited journal and research spots between individuals.

At the same time, however, academic researchers often recognise themselves and their work as part of a larger scientific community, in which everyone implicitly collaborates beyond the boundaries of institutions on the larger goal of creating knowledge and increasing understanding. This communal view of academic research, when embraced, can decrease competitive sentiments.

Cooperation

Cooperation is distinct from collaboration: in its broadest definition, it includes any behaviour beneficial to others. Following this definition, cooperation is inherent to modern academic practice: researchers share their knowledge through formal publications, for example, or discuss their findings during conferences. Hence, researchers often tend to cooperate even when competitive tensions exist between them.

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Slight competition, high cooperation

Competition

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High competition, no cooperation

Competition

The modern academic climate is highly competitive due to the limited financial and human resources. At a more individual level, individual researchers compete for research positions and journal spots as well as general esteem, the latter even within collaborations and cooperative relationships.

Many academic researchers, however, also recognise themselves and their work as part of a larger scientific community, in which everyone implicitly collaborates beyond the boundaries of institutions on the larger goal of creating knowledge and increasing understanding. This communal view of academic research, when embraced, can decrease competitive sentiments.

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Cooperation

Cooperation is distinct from collaboration: in its broadest definition, it includes any behaviour beneficial to someone else. Even within highly cooperative relationships, there may then be cooperative behaviours that the individuals concerned are not comfortable with. Individuals may, for example, fear being scooped or receiving negative judgement when sharing information on their research ideas and (failed) attempts.

E. Informed consent GICCo evaluation

Consent form Master's thesis "Competition and cooperation in academia"

You are being invited to participate in a research study on competition and cooperation in academia. This study is being done by Enya Berrevoets for her Communication Design for Innovation (CDI, formerly Science Communication) Master's thesis at the TU Delft.

The purpose of this research study is to learn how academic researchers in microscopy-related fields navigate the social aspects of academia. The data will be used for the thesis and any publications that may follow from it.

You are asked to use and provide feedback on the Guide for Introspection on Competition and Cooperation (GICCo), which was developed in the context of the thesis project.

To the best of our ability your answers in this study will remain confidential. Your answers will be used in the thesis anonymously and we will take that that they will not trace back to you. Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any questions you do not feel comfortable answering.

Contact information
If you have any questions or concerns about this study, do not hesitate to contact the researchers at: Enya Berrevoets (head researcher): e.s.berrevoets@student.tudelft.nl Éva Kalmar (supervisor): e.kalmar-1@tudelft.nl
I have read and understand the information presented above and agree to participate in this study.

Name
Date
Signature