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Shared Mental Models And Perceived Proximity: A Comparative Case Study

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Shared Mental Models And Perceived Proximity: A Comparative Case Study

Structured Abstract

Purpose
The aim of this study is to understand how virtual teams experience perceived proximity. Existing literature suggests that perceived proximity can be achieved through quality communication and increased identification. However, not much is known as to how these two may be achieved within the context of virtual teams.

Design/methodology/approach
We address our research question through a comparative case study, with the help of two virtual teams of software developers and we adopt a subset from the Constructivist Grounded Theory Method procedures for the purposes of coding to understand the potential explanations regarding the two teams' differences in perceptions of perceived proximity.

Findings
Our study shows that shared mental models support quality communication and team members to identify with the shared values of their team. Quality communication is easier achieved when the team shares a dynamic and evolving understanding of the tools for communication and collaboration. We also draw attention to the importance of how work is organised and the influence of the temporal dimension on virtual teams beyond the temporal organization of collaborative work.

Originality/value
The value of this study is found in its contribution towards the development of a formal connection between perceived proximity and shared mental models, that is empirically grounded, and which holds an explanatory value in addressing how perceived proximity can be supported rather than compromised.

Keywords: virtual teams; perceived proximity; shared mental models; grounded theory method; comparative case study

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Shared Mental Models And Perceived Proximity: A Comparative Case Study

1. Introduction

Virtual teams are becoming increasingly common as organisations seek to identify the best talent available (Panteli et al., 2019). For this reason, there is extensive research that looks into the challenges faced by virtual teams (Gilson et al., 2015). Among these challenges, the geographical distribution of the team members has been repeatedly identified as the greatest one (e.g., Cummings & Haas, 2012; Kotlarsky et al., 2007; O'Leary et al., 2014), with a negative impact on performance and outcomes (O'Leary et al., 2014; O'Leary & Cummings, 2007; Siebdrat et al., 2014).

However, research suggests that perceived proximity can outweigh the negative consequences of geographical distance (e.g., Cha et al., 2014), where perceived proximity is defined as "one person's perception of how close or how far another person is" (Wilson et al., 2008, p. 979). Studies show that perceptions of distance may not be related to the objective distance, but may stem from social, cultural and other differences among team members (Siebdrat et al., 2014). In this vein, empirical studies have unearthed a variety of factors that compromise perceived proximity, including personality differences, demographics and expectations around challenges with virtual collaboration (e.g., Magnusson et al., 2014), low awareness of other members' local conditions which may cause stress (e.g., Nurmi, 2010) and the degree of dispersion of the team (number of isolated members, number of sites etc.) (e.g., Prasad et al., 2017). However, presently, not much is known about how perceived proximity can be supported. Wilson et al. (2008), for example, in their conceptual work suggest that perceived proximity can be achieved through quality communication and increased identification.

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Quality communication in this context is understood as being "frequent, deep and interactive" (Wilson et al., 2008, p. 986), and identification as one's cognitive connection or how team members self-categorise with respect to their team and its members (Dutton et al., 1994). Wilson et al. (2008) further identify a set of individual and socio-organisational factors that influence communication and identification, such as prior experience and structural assurances, respectively. This is certainly intuitive. However, a greater understanding is necessary as to how quality communication and increased identification may be attained in order to support organisations in creating conducive environments for distributed teams towards experiencing perceived proximity.

We address this through a comparative case study, with the help of two virtual teams of software developers. Team A is an ad hoc, self-managed team whose members experience high perceived proximity. Team B is part of a global software company and its members do not experience perceived proximity. The comparative research design allowed us to contrast the different functionings between the two teams and understand the potential explanations regarding the differences in perceptions of perceived proximity.

This research contributes to Information Systems research through the formalisation of links between perceived proximity and shared mental models, that is empirically grounded, and which holds an explanatory value. Shared mental models reflect "an organized understanding or mental representation of knowledge that is shared by team members" (Mathieu et al., 2005, p. 38). This study responds to previous calls regarding the role of shared mental models during team work (Cummings & Haas, 2012). We show that shared mental models support quality communication and help team members identify with the shared values of the team. Our study also highlights that quality communication is easier achieved when the team shares a dynamic and evolving understanding of the tools for communication and collaboration. In doing so, the study addresses one of the challenges identified by Gilson et al. (2015) in relation to the use

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and adaptation of traditional and emerging information and communication (ICT) tools in the context of virtual teams.

The research further contributes to practice. In a world where virtual teams are becoming the norm, it is not only the work that needs to be managed, but also the team's dispersion and its members' perceptions (Espinosa et al., 2006; Panteli et al., 2019); understanding how these can be improved can have positive knock-on effects on their performance and productivity, as organisations and managers will be better placed to understand what team members need from each other and what teams need from their organisations.

In what follows, we provide an overview of the relevant theoretical background of our study and we then move on to offer details on our research design, our data collection and our data analysis techniques. Next, we present our findings, followed by a discussion of our study's implications for research and practice.

2. Background

In this section, an overview of the challenges of virtual teams is presented, followed by a discussion on perceived proximity with the view to showcase its importance, its potential usefulness in addressing these challenges and the open questions around it. Shared mental models are introduced in the next section as they form the theoretical lens of this study. The relevance of this theoretical lens emerged following data analysis and the use of Grounded Theory Method (GTM) procedures (cf. Method). We choose to present this theoretical background first for clarity purposes, in line with other studies using GTM (e.g., Volkoff et al., 2007), in order to sufficiently contextualise our study (Dunne, 2011).

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2.1. *Virtual Teams and the Challenge of Distance*

Distance between team members is among the most critical factors that influence the performance and outcomes of team work, because distance allows for fewer opportunities for interpersonal relationships (Alsharo et al., 2017) and thus poses a series of challenges: inability to build trust, poor or no knowledge sharing, poor communication, ineffective decision making, poor leadership and bias, among others (Panteli et al., 2019). In some cases, distance between team members can lead to a sense of isolation with negative consequences for one's wellbeing (Holton, 2001; Prasad et al., 2017), or allow for a mentality of 'out of sight-out of mind', whereby team members may be overlooked because they are remote (Sewell & Taskin, 2015) or may disengage from their tasks because they cannot be monitored (Chidambaram & Tung, 2005). In all cases, it has been suggested that as the spatial distance increases, the teamwork quality is expected to decrease because a lot more effort is required for communication, collaboration, and coordination (Cha et al., 2014).

To overcome these challenges and bridge the distance between team members, contemporary virtual teams tend to make heavy use of ICTs, which allow them to transcend the geographical boundaries (Saunders & Ahuja, 2006). However, the distance between virtual team members is not always just spatiotemporal. As virtual teams become more on more diverse nationally and culturally, complexity increases (Siebdrat et al., 2014) and ICTs may no longer be sufficient to substitute social presence or mediate the richness of nonverbal cues (Magni et al., 2018), both of which are critical for effective virtual collaborations (Makarius & Larson, 2017). As a result, existing research has begun highlighting the significance of perceived proximity for virtual teams. This is discussed in the following section.

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2.2. *Perceived proximity*

Perceived proximity is defined as one's perceptions with regards to how far or how close another person is (Wilson et al., 2008). It is often referred to as subjective or cognitive distance (Siebdrat et al., 2014), or psychological proximity (Cha et al., 2014), which captures the fact that objective and perceived proximity may be out of sync (Wilson et al., 2008). In this sense, distance may extend well beyond the geographical and temporal distance and incorporate that of social, cultural and psychological distance. In this study, we adopt the term of perceived proximity.

In cases of high perceived proximity, we observe a paradox where team members are 'far-but-close' (Wilson et al., 2008), which counteracts the negative effects of objective distance, such as cross-cultural differences (Espinosa et al., 2006). The paradox of far-but-close is well documented in the literature, and studies have shown that individuals may feel close to each other despite being far away. Conversely, team members may feel distant despite being near to each other (Kolb, 2013). What this suggests is that there exists a contradiction, whereby the "perceived distance does not increase linearly with actual distance" (Siebdrat et al., 2008). Intuitively, one would expect that individuals who are geographically and/or temporally distributed, with possible additional differences, such as cultural and national, would feel distant from each other. When seen in isolation, this makes for a logical and compelling argument; yet, studies show that this is not always the case (e.g., Hummel et al., 2016; Siebdrat et al., 2014).

There are different operationalisations of perceived proximity within the existing literature. For example, Cha et al. (2014) approach it as a combination of spatial, temporal and social distance and quantitatively explore these types of distances drawing from Construal Theory (Lim et al., 2012). Wilson et al. (2008, p. 984) view perceived proximity as "the product of communication and identification processes and the individual and socio-organisational factors affecting

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them". Similarly to Wilson et al., Chae (2016) approaches perceived proximity as a dyadic and asymmetric construct with cognitive and affective components. Comparing these two approaches, the latter allows for capturing the intensity, frequency and quality of communication, which supports team members in developing a common ground and shared identity (Espinosa et al., 2006), which in turn reinforce each other, reduce uncertainties and the perceived distance among team members. For example, O'Leary et al. (2014), while operationalising Wilson et al.'s approach within a mixed methods study, found that, besides the strong links between perceived proximity, frequency of communications and shared identity, ICT-based communications denote reliability, dependability, likeability and accessibility, i.e., that communications hold a symbolic significance.

Certainly, the quality of communication and high identification with one's team seem intuitive enough to influence perceived proximity, and existing empirical studies have validated their relevance for both collocated and virtual teams (Kidron et al., 2016; Lähdesmäki et al., 2019; O'Leary et al., 2014; Ruiller et al., 2019). Yet, little is known how these can be practically achieved or what is the influence of other factors, such as organisational ones, on perceived proximity. Notable exceptions include two studies showing that the management style can both facilitate and hinder team interactions (Eisenberg & Krishnan, 2018; Makarius & Larson, 2017), and research by Ruiller et al. (2019) who explore how management practices can facilitate perceived proximity, and investigate leadership aspects towards supporting virtual teams' in forming a shared identity.

In this paper, we introduce shared mental models, as an alternative integrative explanation as to how quality communication and increased identification are achieved, leading to perceived proximity, which emerged from our empirical material. These are presented in the next section.

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2.3. *Shared Mental Models*

Shared mental models are defined as "an organized understanding or mental representation of knowledge that is shared by team members" (Mathieu et al., 2005, p. 38). In this study, we draw from the work of Cannon-Bowers et al. (1993), which refers specifically to team work and has been extensively applied within the team work literature (Windeler et al., 2015; Yang et al., 2015).

Shared mental models are commonly used to investigate team effectiveness (Mathieu et al., 2008). This is because, to work effectively within a team, team members are required, to a certain extent, to anticipate each other's behaviour, have a common understanding of what is required to complete a certain task, and share a common objective. Against this background, shared mental models can be understood as the knowledge structures that are held by the members of a team (Jonker et al., 2010). Indeed, early work on traditional teams has shown that team members who share mental models are better able to understand each other's needs and expectations (Cannon-Bowers et al., 1993; Espinosa et al., 2015), thereby increasing their effectiveness (Edwards et al., 2006).

Shared mental models have four distinct models, namely equipment, task, team and team (Cannon-Bowers et al., 1993) (Table 1). The *equipment model* concerns an understanding with respect to the tools necessary for the completion of a task or a project, and recently this begun being referred to as the technology model, thereby underlying the reality of contemporary work conditions, where most of the used tools are ICT-based (Mathieu et al., 2008). The *task model* reflects the understanding about what needs to be done for completing a certain task, and *the team member model* denotes the awareness about the other members' skills, desires, habits, beliefs etc.. Finally, *the team interaction model* reflects what is known and/or believed about team processes (Cannon-Bowers et al., 1993; Mohammed et al., 2000).

Table 1. Types of Shared Mental Models (Cannon-Bowers et al., 1993).

Models	Definition
Equipment model	Shared understanding of the tools necessary for the completion of a task or a project
Task model	Shared understanding about what needs to be done for the completion of a task or a project
Team member model	Awareness of each other's skills, desires, habits, beliefs etc.
Team interaction model	Shared understanding of what is known and/or believed about team processes

Shared mental models do not need to be identical, and not all models need to be shared. While it is beneficial to share an understanding about the necessary tools for the completion of the task (equipment model), it is not mandatory and mere familiarity may be enough. However, the other three models need to be shared. Cannon-Bowers et al. (1993) underline that shared understandings with regards to what needs to be done for the completion of that task (task model), what processes are needed and how these need to unfold (team interaction model) are critical towards the success of the team. They further posit that the team member model needs also to be shared so that each member appreciates the others' skills, competences, habits etc.

2.4. Perceived Proximity and Shared Mental Models in Virtual Teams

Within the context of virtual teams, distance inhibits team members to appreciate "the low-level, detailed, and contextualized features of their fellow group members' knowledge structures" (Wilson et al., 2013, p. 640). However, these "knowledge structures" are the shared mental models (Cannon-Bowers et al., 1993; Jonker et al., 2010; Mathieu et al., 2005). We posit that when distributed team members hold a shared understanding regarding their tasks, each other's skills and habits, the team's processes, and the tools they need to use, then they are more likely to communicate more frequently and efficiently, as communications will be more targeted (Kolb et al., 2008). Equally, we expect that, for these reasons there will be less frictions regarding collaborative work and more opportunities to associate and connect with each other, thereby facilitating identification processes among them. Following from Wilson

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et al.'s (2008) conceptualisation of perceived proximity, this should shorten the perceived distance among distributed team members.

3. Method

This paper builds on the case study design for the purpose of offering rich descriptions of grounded-on-the-data phenomena (Miles & Huberman, 1994). It is designed as a comparative case study using a two-case design for the triangulation of our findings. We employ Grounded Theory Method techniques for offering rich descriptions of observed phenomena (Wiesche et al., 2017, p. 695), to serve the aim of this study. In the GTM tradition, data analysis and interpretation take place iteratively and inform each other to explore the relationships among concepts and the relevance of theories and existing literature for the interpretation of phenomena (Volkoff et al., 2007), "while simultaneously considering the context in which [these] phenomena are embedded" (Strong & Volkoff, 2010, p. 734). It is through this process that we identified shared mental models as relevant for investigating perceived proximity.

3.1. Research Sites

Team A. Team A is a small, self-managed team of software developers. They have been collaborating for more than six years on an doc basis and only for pursuing projects which they consider as learning opportunities. Throughout this period, four of the team members (Brian, Carl, Dennis, Mike) have been fully employed as software developers under flexible working arrangements, which allows them to pursue projects of their own.

The team typically works with businesses to develop bespoke business solutions. Their last two projects involved Internet of Things (IoT) solutions for monitoring food safety in a food manufacturing plant. These two projects were both for the same client, who granted them office space in central Athens, Greece. Since then, three of the team members (Al, Carl, Dennis) have been making use of the office space, but are not required to and often choose to work from

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home. Brian and Mike have always been collaborating with the team remotely, and continue to do so (Table 2).

The typical tools they use for collaboration and coordination are GitHub (for software development), Skype and Slack (for communication among them) and Jira for project management. They often use the screen sharing functionality of these tools and make little to no use of email and phone.

Table 2. Team A

ID	Location	Time Zone	Working Terms	Background and Expertise
Al	Athens, Greece	GMT +2	Collocated member (working out of the same office, but often working from home)	Junior: Front End Software Developer
Brian	Thessaloniki, Greece	GMT +2	Permanent remote member	Expert: Back End Software Developer
Carl	Athens, Greece	GMT +2	Collocated member (working out of the same office, but often working from home)	Mid: Full Stack Developer
Dennis	Athens, Greece	GMT +2	Collocated member (working out of the same office, but often working from home)	Expert: DevOps, Mobile, Back End Software Developer
Mike	Leicester, UK	GMT	Collocated member (working out of the same office, but often working from home)	Expert: Full Stack Developer

All names replaced with pseudonyms to maintain anonymity.
GMT: Greenwich Mean Time.

Team B. Team B is similarly a small team. It is part of a multinational telecommunications company that started off as a start-up, but grew considerably in only few years with offices today in the U.S.A, Belarus, Pakistan and the U.K.

The team comprises of four members. Three of them are collocated, i.e., they work together in the same office space in Leicester, U.K., and are expected to work on-site. The fourth member (Maxim) works out of the company's offices in Minsk, Belarus. One of its members, Arjun, is the Software architect of the company. This means that, by default, he participates in all the

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developers' teams (on- and off-site) and has overview of the development progress, in order to identify and develop solutions for critical issues pertaining to software development. However, Team B is his primary affiliation because this team is responsible for developing and maintaining core tools and features for the company's commercial software. As part of their work, Team B interfaces with other teams, including the Product team, the Sales team, and other developers teams, the latter being located in Minsk and working on features for the core tools of the commercial suite.

The tools they use for collaboration and coordination are GitLab (for software development), Slack (for communication), which was gradually being replaced by MS Teams at the time of our study, Jira for project management and Miro for agile collaboration. They also use email a lot and often opt for screen sharing while communicating over the phone.

Table 3. Team B

ID	Location	Time Zone	Working Terms	Background and Expertise
Arjun*	Leicester, UK	GMT	Collocated member (always working out of the same office)	Expert: Software Architect
Peter	Leicester, UK	GMT	Collocated member (always working out of the same office)	Expert: Software Developer and Test Engineer
Laura	Leicester, UK	GMT	Collocated member (always working out of the same office)	Junior: Full Stack Developer
Maxim	Minsk, Belarus	GMT +3	Permanent remote member	Mid: Software Developer

All names replaced with pseudonyms to maintain anonymity.
GMT: Greenwich Mean Time.
* Arjun, being the Software architect of the company is member of all the company's teams by default.

3.2. Data Collection and Analysis

Our empirical material is naturally occurring material which was collected from multiple sources (Cunha et al., 2019), and semi-structured interviews, in line with the guidelines for case study research (Yin, 2003) and ethnographic principles (Denzin, 1996) (Table 4).

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During our observations of Team A, we noticed frequent and meaningful communications, which seemed to exceed the strict confines of 'work'. In the first instance, we considered this an indication of the paradox of far-but-close, as introduced by Wilson et al. (2008) where team members are remotely located but feel close together. This was later confirmed by our data analysis:

There is this distance between us, it's true, but all this means is we need a little longer to solve problems, or that we need to do a screen share. This is the disadvantage. But we solve this with technologies. Otherwise, we are more friends than collaborators I'd say, because we are on the same wave length, we understand and help each other (Al, Team A).

In addition, we observed that, even when all the Athens-based team members were working on-site, they communicated via ICTs; we theorised that this should enhance perceived proximity among remote members, because it allowed them to partake to the discussions of the collocated members.

Table 4. Overview of Data Collection

Team	Team Members	Interviews	Observations
Team A	5	• 1st round of interviews: January 2018 to May 2018 (5 interviews via Skype): ○ Al – 63 min ○ Brian – 43 min ○ Carl - 57 min ○ Dennis - 80 min ○ Mike – 81 min • 2nd round of interviews: June and July 2018 (2 follow up interviews via Skype to clarify concepts and emerging ideas): ○ Brian - 52 min ○ Mike - 45 min Total: Approximately 7 hours of interviews, recorded and transcribed in Nvivo	• May 2017 – June 2018: ○ handwritten notes of observations of more than seven virtual meetings (Skype), observed by the first author, ○ handwritten notes of observations (twice per week) of remote member Mike, observed by the first author (the two being collocated). • July 2018: ○ on premises observations of collocated members (every day for 1 week, observed by the first author at their offices). • Audio recording of approximately 3 hours long virtual meeting via Skype, observed by the first author, transcribed in Nvivo.
Team B	4	• 1st round of interviews: February and March 2019 (4 interviews via Skype):	• February 2019: ○ Handwritten notes of observations during visit on-site (UK offices),

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		○ Arjun – 67 min ○ Peter – 48 min ○ Laura – 52 min ○ Maxim – 57 min Total: Approximately 4 hours of interviews, recorded and transcribed in Nvivo	observed by the first author (single day visits for a week), prepared post visit.

During the first round of interviews with Team A, we focused on understanding how the team members collaborate and coordinate themselves for the delivery of their current and previous projects. Throughout the interviews, our predefined set of questions was used solely for probing purposes (Table 7 in the Appendix). The second round of interviews took place two months later with two team members, as a follow-up to the first round. The aim was to gain a better insight into particular issues and confirm the reliability and validity of our results. Observations were undertaken by the first author both on site (i.e., at the team's office space in central Athens), in the UK (observing the remotely located member, Mike) and observing online meetings via Skype, where she was given full access. Through the extensive period of our observations, we had the opportunity to delve deeper into the team members' behaviour during their work.

Team B was later added in our study for comparison purposes. We established early on that the team members were not experiencing perceived proximity. One of the UK-based members, for example, referred to the Belarussian member as "a name on a piece of paper" (Laura, Team B), and interviews and observations further confirmed this. UK-located members were observed on-site, and the Belarusian remotely located member was only interviewed (Maxim). While our engagement with this team was shorter due to access reasons, we were still able to observe their collaboration on-site during online meetings and phone calls, which allowed us to compare our evolving understanding of our findings and interpretations.

The observations and interviews with the two teams were undertaken by the same researcher (first author). While with Team B, the researcher functioned clearly as an outsider, with Team

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A, due to our prolonged engagement, the role slightly changed from that of the outsider to quasi-outsider, and our ties strengthened over time (Fayard & Van Maanen, 2015).

Data collection and analysis were conducted in tandem, while still in the field, and while developing our interpretations. We adopted a partial set of GTM procedures, strictly for structuring and analysing our empirical material from the two case studies, in order to offer a rich description of the observed phenomena (Wiesche et al., 2017). We adopted Charmaz's Constructivist Grounded Theory Method (GTM) procedures for coding (Charmaz, 2006), which allowed us to use existing theories from the literature of virtual teams and the concept of perceived proximity as the "springboard" for inductive theorising (Zamani & Pouloudi, 2020, p. 12), while coding close to our data and remaining open to any emerging concepts. We used the theoretical components of perceived proximity (communication, identification) and theories such as Kolb's flow and connectivity (Kolb, 2008; Kolb et al., 2008) as sensitising devices to query our material in relation to what quality communication or increased identification may mean or how they can be achieved, having already established that Team A experiences perceived proximity, whereas Team B does not.

We first familiarised ourselves with the empirical material, preparing memos after our observations and while reading our material. Following the Constructivist GTM approach to coding, we began with initial coding, drawing from broad categories from the literature, and coding line by line, and often at paragraph level. This was conducted via frequent discussions among the two authors to establish the reliability of the evolving coding scheme, and while consulting with our memos. An example of initial coding can be seen in Figure 1. We then moved to focused coding. We grouped initial codes together to create richer dimensions around our queries, and focusing our coding more around those codes with the strongest analytical power (Zamani & Pouloudi, 2020), comparing our codes across participants and cases. It was during this process that shared mental models emerged as relevant in our study. We noticed

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that Team A members were referring to aspects of sharedness of understanding (e.g., being "on the same wavelength" (Al, Team A), having "a mutual understanding" (Brian, Team A)), whereas, in many instances, we had the opposite observations for Team B.

To establish the presence or absence of shared mental models, we compared the descriptions within teams with regards to their use of ICTs, task allocation and development methodologies in use, their job roles and those of their peers, and the team's processes, to identify overlaps or discrepancies along the lines of the four types of shared mental models, as described by Cannon-Bowers et al. (1993) (Table 1). To do this we further drew from our observations, to corroborate participants' descriptions with our own observations.

After focused coding, we revisited our coding scheme and our memos in order to proceed with a cross-case comparison and abstract our codes further. This allowed us to identify plausible explanations regarding the identified differences and further theorise as to how these differences may relate to the differences observed regarding perceive proximity. Namely, we identified three main elements lending themselves for theoretical explanation: the shared dynamic understanding of tools and ICTs, the different degrees of sharedness and the work organisation, which constitute the core categories of our analysis.

Table 5 shows an overview of our data analysis. Table 8 (Appendix) shows an example of our coding process and Table 9 shows our methodological reflection. While this process seems linear, in reality, it is iterative.

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"We have a stand up, it's a small one, 5 to 10 minutes, ideally 5 minutes, then meeting, when each member of the team talks about what he has done yesterday and what he is going to do today. Also, if he has some concerns about his current tasks, he just notifies us. So just a heartbeat meeting about the situation of his team. Usually, I am working on software tasks because we have 3 hours difference between the Minsk office and the UK office right now. So I don't have to change. I can't communicate with a team because they're asleep."

Coded as the initial code 'Frequency of Communication'

"In JIRA, you can have, like, stories. So, we are using JIRA in a very convoluted way, not the proper way. So what we actually do is, for a specific project, for example, the [System 1] project, we create a new project and then each of us we will create stories and for each story, there will be tasks. And those tasks will be given to developers and the stories give them the reason why these tasks have been initiated."

Coded as the initial code 'Equipment Model'

Figure 1. Example of Initial Coding

Table 5. Stages of Data Analysis

Stage	Description of the Process
Familiarisation	Review of the empirical material, involving memoing, and note taking around observations and emerging ideas
Initial coding (based on constant comparison)	Initial coding around main themes, using our memos and consulting with existing literature on virtual themes.
Review of codes and themes	Initial codes were reviewed by the two authors, ensuring that they reflect accurately the topic of research, that codes are mutually exclusive (no overlaps between codes) and that they are exhaustive (all relevant material coded into codes) (Miles & Huberman, 1994).
Focused Coding	Reviewing of evolving coding scheme for emerging patterns through constant comparison between the two cases, and among our participants. Links between emerging concepts were theoretically elaborated and initial codes were grouped together into larger categories. In light of the relevance of shared mental models, some initial codes were grouped together, others were relabelled and others were merged (Urquhart, 2012). Theoretical saturation was examined (no new themes emerging and the theoretical categories were saturated as a result of coding).
Cross-case comparison	Findings from the two cases were compared to identify possible explanations for the interpretations. The initial results were shared with a key informant from Team A to assess whether there are any misconceptions and whether our interpretations are valid and plausible.
Reporting Findings	Final analysis of selected quotes, development of chains of evidence (Table 8 in the Appendix), revisiting the literature and developing findings.

4. Findings

We now turn to presenting our findings. We organise our findings around the three core elements – different degrees of sharedness, shared dynamic understanding of tools and ICTs

and work organisation, which offer theoretical explanation as to why Team A experiences perceived proximity whereas Team B doesn't.

4.1. Degrees of Sharedness

Our findings indicate that the two teams exhibit different degrees of sharedness of shared mental models. Team A enjoys a common understanding across all four types of shared mental models, whereas Team B members share only the equipment model and the team interaction model, the latter only partially (Table 6).

Table 6. Degrees of Sharedness among the two teams

	Team A	Team B
Shared Mental Models		
Team Member Model	●	
Team Interaction Model	●	
Task Model	●	○
Equipment Model	●	●

Note: the black circle denotes complete overlap, the white circle denotes partial overlap. The lack of circle denotes no overlap at all.

First of all, Team A has been composed on the basis of complementary skills where everyone is aware of each other's competencies *(team member model).* This allows them to know who is better suited for particular tasks and therefore turn to him for support when they need help:

Al: *"Depending on the problem we work in twos or threes. Many problems are solved by me or Dennis. Others are solved by Carl with Dennis, or Carl and myself. It depends on the feature, because not all of us have the same skills." (Team A)*

Being a self-managed team, Team A has no formal processes in place. However, and despite organising dynamically, they do share a common understanding as to how coordination and collaboration takes place *(team interaction model),* which incorporates everything from the use of software tools and ICTs, to the management of projects and task allocation. Most importantly, this shared understanding offered by Team A members corresponded with our own observations of the team's processes for e.g., communicating with clients, assigning tasks

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etc. In more detail, all Team A members described identically how tasks are allocated *(task model)*. They collaboratively divide projects into smaller tasks, which they then add on their Kanban board in Jira. From there, each member is responsible for picking up their own tasks, and when they complete them, Jira gets updated, sending a notification to the team's Slack channel, informing all members and providing increased transparency regarding progress (Figure 2). Finally, as far as their arsenal of tools and ICTs is concerned, Team A members have co-developed it. Often ICTs are chosen even in instances of co-location; when the Athens-based members share the same office, they rarely move away from their desk to somebody else's to collaborate. Instead, they communicate via Slack and Skype using the chatbox. While unusual, this is a conscious choice that allows remote members to remain on top with progress, having access to all discussions.

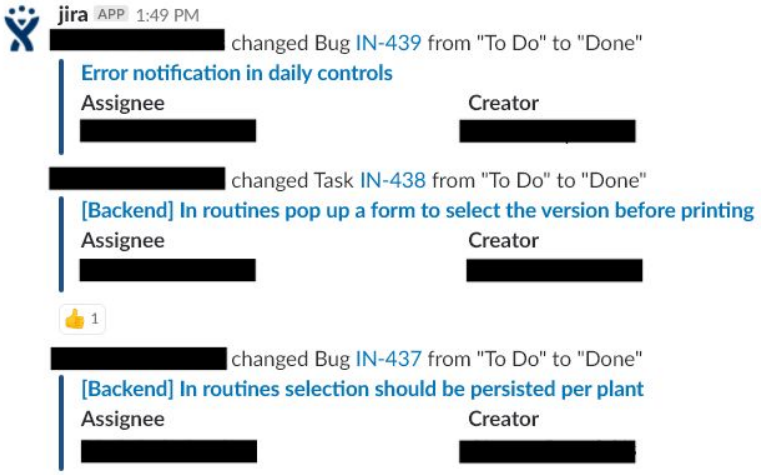

Figure 2. Screenshot from Team A's Slack channel, showing Jira updates and informing the team regarding task completion.

Contrary to Team A, some members in Team B seem either less aware of or less interested in each other's job roles and expertise. While in principle they know the roles and the responsibilities of each team member, in practice, remote members turn almost exclusively to the most senior person, i.e., the Software Architect, for support, which has been causing frustration and frequent problems:

Arjun: "All the issues they are raising can be actually fixed if they speak to each other [talking about other developers in Belarus]. So when it comes to [System 1], they don't have the ecosystem knowledge, they will be asking the exact same question that Maxim has asked me." (Team B)

However, further probing into this revealed that the root cause for such discrepancies lies with how the team processes have been set up and how tasks are allocated. Team B has formal processes in place with regards to management and coordination *(team interaction model).* While all members indicated having a shared understanding around these, further inquiries have shown inconsistencies. For example, regarding Sprints and the development methodology, Peter noted: "*the Belarus team, their general methodologies are different to the Leicester team, but then obviously for those teams to communicate when they're working..."* and explained that the Belarusian part devotes more time to sprint planning (3 days), whereas UK-based members devote less (one day), which results in having unsynchronised development cycles within a single team.

Other discrepancies stem from task allocations *(task model),* too. At company-level, tasks are decided and prioritised by the Product Team, the Team Leads and the Software Architect, and then distributed to the developers' teams. From then on, team members pick up tasks from the Kanban board depending on their skills, expertise and the priority of the task *("Every team has set tasks that they are requested to do by the Product Team. So, we use Jira to choose tickets. (Laura, Team B)).* While there is a wealth of information at task-level, information regarding how tasks relate to each other to form the larger system is not always available. Most importantly, such information is not communicated to the developers in Belarus, including Maxim who only receives bite-sized information, decoupled from their wider context. Maxim is often unaware that the plugins he handles are meant to be available for different third-party

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commercial packages, and thus far this has resulted in bouncing tasks back and forth between the UK and the Belarusian members or developing plugins from scratch multiple times:

Maxim: "They tried to delegate this task to each other. (...) So the back end team tried to explain to our Belarus guys what is going on and that you should fix this task, it will be easier to fix this task on the front end side. But they explained it unclearly, in my opinion and in my Belarus colleagues' opinion." (Maxim, Team B)

Arjun: "They can take that the plugin must only be developed for [system 1]. But when everyone said that, when that work is finished, then we move to [system 2]. The approach that they took to work on the plugin for [system 1] didn't work. (...). They only focus on the task, they don't focus on the big picture (...). If this functionality works in [system 1], it needs to work on every [system]." (Team B)

Finally, like Team A, Team B uses several tools and ICTs for collaboration, coordination and communication; however, they have appropriated some of these tools for their own purposes. Jira, for example, is used not only for developing and tracking user stories, but also as a repository of information, storing tickets and the full context under each user story. Even though Jira has been appropriated for their purposes, and despite the differences in experience and expertise, all members are aware of these adaptations:

Arjun: "We are using JIRA in a very convoluted way, not the proper way. So what we actually do is, for a specific project, for example, the [System1] project, we create a new project and then each of us we will create stories and for each story, there will be tasks. And those tasks will be given to developers and the stories give them the reason why these tasks have been initiated. And from there, they also know who has created each story, each task, when and how, so we can trace it back if needed." (Team B)

However, Team B makes use of email, too, especially when a member wishes to ensure some kind of accountability or a follow up action:

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Peter: "I sent him an email [to the Team Lead] so I know I have an email to show about this" (Team B)

4.2. Shared Dynamic and Evolving Understanding of Tools and ICTs

One of the main areas we focused was the means of collaboration and communication within the two teams. Due to the nature of work, both teams use a number of tools for software development and ICTs for communication and collaboration, and our analysis suggests that all members have a shared understanding why these tools have been chosen, how they should be used, and they use them accordingly *(equipment model)*.

However, we observed differences among the two teams. Team A's choices regarding their arsenal of tools and ICTs have taken place in a collaborative fashion:

Mike: *"We [emphasis placed in 'we'] decided on which tools to use. It's not like there are many choices, four or five serious solutions. But we had to make it work, lightweight and all, and we decided what to use" (Team A).*

In addition, since the beginning of their collaboration, they have been trying out and adopting different tools on a needs basis, particularly for development purposes. In the beginning, when projects were smaller, they were using fewer tools, but as projects started becoming more complex, they began using more tools, integrating them together to achieve higher automation:

Dennis: "We have to upload all of this to a server somewhere. (...) I have added this task in GitHub, but then, when it was time for deployment, we got TeamCity. We linked this to GitHub and every time we add new code in GitHub, it triggers TeamCity, TeamCity runs our code and publishes it to the server automatically. Before TeamCity, there were days with 30-40 commits, so imagine, one person maintaining the bit process and the deployment process on his own. Now it's fully automated." (Team A)

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This approach has allowed Team A to reduce communications regarding project progress and coordination to a minimum:

Dennis: "For coordination, once I create a task, somebody will pick it up, they don't have to communicate with each other too much about this." (Team A)

Therefore, by remaining flexible regarding their use of tools and ICTs, Team A has managed to reduce the amount of work-related communications among them, and adopt a dynamic and evolving portfolio that supports them in adapting every time to the needs of the project they work on.

This is not the case for Team B. All choices are made by the company's Tech Lead, who is external to the team. These choices are then pushed top-to-bottom for adoption. At the time of our study, Team B was moving from Slack to MS Teams, following a decision to adopt a solution that would allow seamless communication with additional stakeholders (e.g., Sales and Support Teams). Like most changes (e.g., Choudrie et al., 2016), this was not particularly welcome, and raised concerns regarding the quality of collaboration among developers, and specifically regarding communications with Maxim:

Arjun: *"The reason is that in Belarus the internet is really bad, there are times we can't talk to them. But through the phone is easy. Since we are [name of company redacted], we can actually call them cheaply. It's nearly free. (…) screen sharing and everything is really bad because of their internet connection and the infrastructure team, they are trying to improve that, but there is a lot of migration." (Team B)*

4.3. Work Organisation

The two teams operate within very different organisational environments, which has influenced their approach to development methodologies. Specifically, while both teams indicate following an agile approach to development, Team A follows Scrum in its pure form, while

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Team B follows a hybrid approach, combining Scrub with elements from the more structured methodologies. In what follows we offer further details.

Team A breaks down project in smaller tasks and lists them into the Kanban board. Each task is assigned a priority (low/medium/high), and is noted as 'to do', 'doing', 'done', 'to do' or backlog'. From there, the team members pick up tasks based on the task's priority and their own skills and capacity. In line with the Scrum methodology, the team has a flat hierarchy without a formal Team Lead or Project Manager, which is possible because they are self-managed. Informally, however, Dennis has taken up the responsibility of communicating with clients:

Al: "Let's say there is an informal hierarchy, Dennis is the face of the team. He gets in touch with clients. But that's about it. He has no other privileges. Sometimes he coordinates us, but he is not our boss, the Manager who would say "you haven't finished this". We are free to decide how much we will work, what we will implement." (Team A)

Team B uses the Scrum methodology in a more structured version due to their need to report more formally to management. Tasks are identified by the Software Architect, the Product Team and the Team Leads. Each task is assigned a priority and points that correspond to the time required to complete it. These points are computed on the basis of the task's complexity and are meant to capture the team's velocity, i.e., how many tasks the team can complete during a single sprint. In principle, velocity and other software metrics are used in the company in order to measure the developers' productivity. In practice, however, it has had negative impacts on team members' willingness to be supportive to each other:

Arjun: "So the junior developers, they don't actually know what this work is, what this ticket is. Some people ask but the thing is they have to be trained a lot. (...) you have to sit with them and train them (...). So that time is never invested in the development team. Since that time is not being invested, all the tasks that junior developers are doing, it's

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just gets blown out of our quota. So a simple task, a 5-point task, just blows up to be 13. So those kinds of stresses really impact the project delivery." (Team B)

Our findings further indicate the relevance of the temporal dimension. Team A has been collaborating for more than six years, with its current composition almost unchanged for the past five, when Mike joined the team. This has allowed the members to build the team processes and the bonds among them. Therefore, the temporal dimension is closely interrelated with how the team is managed. Among the first things we noticed were the frequent online communications among them, extending well beyond work-related matters, on personal and family issues, and the commonalities in relation to hobbies, values, and beliefs, which potentially allowed them to reinforce their bond between them. On the one hand, the frequent and meaningful communications were the result of high automation in the development-related processes that saved them from unnecessary coordination activities; on the other hand however, without having enough time available as a team, they wouldn't be able to discover and establish that common ground, subsequent socialisation processes (i.e., online gaming) and possibly future collaborations.

When we entered the field, Team B was working together for the past fifteen months; however, all its members had been previously members of different teams. Again this is related to the structural changes happening in Team B and the company in general. The company has undergone several changes, and from being a start-up, they opened up branches in three more countries. This growth was sudden rather than organic and has led to restructuring and staff turnover, with several senior developers with intimate knowledge around the ecosystem leaving the company:

Laura: "The teams have changed a lot recently… People leaving, there's structural changes… The team that was originally part of [System1], the Team lead was moved out to be part

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of [System2], I was moved into a different team, because a new team was created and people were moved into there. There's been a lot of moving around." (Team B)

There were ongoing concerns among them with regards to conflicting priorities and values, and it was suggested that the Belarussian developers, specifically Maxim, are of a different mindset: they work strictly to specifications without considering whether their solutions are "good for the company and the product" (Arjun, Team B). Yet, considering our finding in relation to the task model and that information in relation to the ecosystem is not passed on to the Belarusian branch, this is expected. In reality, the Belarusian branch is being managed more as a supplier to whom the UK branch is outsourcing work, rather than as an organic part and a member of the company.

5. Discussion and Implications

The aim of this study was to explore how virtual teams experience perceived proximity.To address this, we designed a two-case comparative case study with two virtual teams, Team A and Team B, where Team A experiences perceived proximity but Team B does not. In what follows, we discuss our findings highlighting the theoretical and the practical implications of the study.

5.1. Theoretical Implications

Our paper extends our understanding on perceived proximity by combining it with shared mental models. Wilson et al. (Wilson et al., 2008) propose that perceived proximity is a function of quality communication and increased identification among team members, which allows them to feel close to each other despite spatial and/or temporal distances. However, drawing from the literature on shared mental models (Cannon-Bowers et al., 1993), our findings extend current knowledge as to how quality communication and increased identification may be achieved, while they further highlight the importance of how work is

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organised and managed: how development methodologies are implemented, how teams are managed and how the temporal dimension may influence teams beyond the temporal organization of collaborative work.

Our first contribution is found along the lines of what quality communication means and how it may be achieved. Existing literature suggests that striking the right balance between frequency and quality of communications among remote team members is critical (e.g., Marlow et al., 2017; O'Leary et al., 2014; Yang et al., 2015). Our findings directly address this by indicating the importance of holding a dynamic and evolving shared understanding regarding the necessary tools for communication and collaboration, rather than a static portfolio of such tools. First, the shared understanding about communications and collaboration tools, in and of itself, allows team members to reduce to a minimum work-related communications, to coordinate better, and to achieve a state of flow (Dennehy & Conboy, 2019; Dery et al., 2014; Kolb et al., 2008) with regards to their connectivity. In contrast, when communications become more intense among team members and more frequent, the resulting hyperconnectivity is counter-intuitive to quality communication (Kolb, 2008; Kolb et al., 2008). Second, being able to adapt the portfolio of tools and ICTs for collaboration and coordination over time allows teams to remain flexible to the changing needs and requirements of their members and those of each project. In this respect, we further address Gilson et al.'s (2015) call for research on how virtual teams adapt or appropriate ICTs for communication and coordination purposes. Our findings show that virtual teams are better positioned to adapt and appropriate their tools when they can make their own choices. Contrasting these findings with studies from the appropriation literature, we posit that this is the case because team members, being the users themselves, have a greater understanding of their own needs (e.g., Schmitz et al., 2016; Zamani et al., 2020; Zamani & Pouloudi, 2020), and can thus make better informed choices as to what works best for them.

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Secondly, the paper makes an important contribution regarding shared mental models. Our findings extend current knowledge on the impact of shared mental models with regards to virtual team outcomes (Cramton, 2001; Mathieu et al., 2008) and indicate that they influence perceived proximity as well. We found that, for perceived proximity, it is useful to hold a shared understanding about the tools in use (equipment model) and the team processes (team interaction model). Having such convergent understanding leads to effortless and effective communication and uncertainties regarding progress become fewer (Cramton, 2001). This further decreases the negative impacts due to discontinuities (Panteli et al., 2019), stemming from different uses of ICTs, which seem to have been the case in similar studies (e.g., Dixon & Panteli, 2010). However, our findings also indicate that it is equally crucial to share an understanding about the structure of the tasks themselves (task model) and the knowledge, skills and attitudes of one's peers (team member model). In our study, Team A shares all four types of mental models, while Team B only two (equipment model, team interaction model partially). In this regard, Cannon-Bowers et al. (1995) have argued that the team member model is crucial because it helps team members adapt their behaviour according to their peers' expectations and needs, supporting smoother collaboration. In addition, Mathieu et al. (2000) point out that when tasks are not repetitive, as for example in project-based software development, a shared task model is critical and influences team processes. We thus argue that it is not enough to operate well as a team nor is it enough to solely execute tasks well, but rather there needs to be some convergence along all types of shared mental models. While it has been argued that not all types of mental models need to be shared (e.g., Cannon-Bowers et al., 1993; Mohammed et al., 2000, 2010; Schmidtke & Cummings, 2017), we underline that previous studies have focused on team outcomes and performance; when the focus moves from team outcomes to perceived proximity, our findings show that all four need to be converging.

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Taking a step back from our findings and considering the two cases on the basis of their differences in order to theorise around the role of the contextual conditions, we draw attention to how these two teams are managed. Assembling on an *ad hoc* basis can be seen as associated with the concept of interpersonal attraction, where people develop an attitudinal positivity for one another (Huston & Levinger, 1978). This attraction is the result of the members' relatedness, which highlights the importance of relative (e.g., similarity), rather than absolute attributes (e.g., status), as well as the significance of relational attraction (familiarity) (Wax et al., 2017). These factors are conducive to shared mental models, as in and of themselves presuppose a common ground, and as our findings indicated, shared mental models support quality communication and help members identify with the shared values of the virtual team, which ultimately lead to perceived proximity.

This is obviously not the case with Team B, which sits within a large organisation and as such is governed by more formal management approaches. Due to its success, the company did not have the time to properly manage its growth, which led to frequent team restructuring and which prohibited team members to build bonds with each other. However, experience within the virtual team is important because it is what helps team members understand each other and how they work (Espinosa et al., 2006).

Next, our findings draw attention to a paradox. The Scrum methodology for software development requires active collaboration between developers and clients (internal or external) (Chan & Thong, 2009). However, Team B is governed by layers of management (Team Leads, Product Team, Software Architect) that function as a buffer between developers and clients, which counteracts many of the benefits of the Scrum methodology, e.g., capturing and developing requirements in a participatory fashion (Dennehy et al., 2019). Further exploration into this would be outside the scope of the present research; however, it does lead to a very interesting question with regards to how agile methods are introduced within large software

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companies, and why these often seem to fail or be rejected by software developers. We posit that teams of software developers, collocated or distributed, who use agile approaches in their practice, require some sense of self-organisation and self-regulation of their everyday so that they can build autonomy, and, in doing so, overcome the complexity that agile software development brings about (Werder & Maedche, 2018).

5.2. Practical Implications

Our study provides a rich description of the different types of shared mental models, whereby each of these can help practitioners in designing and establishing small virtual teams. Through our comparative case study, we illustrate two examples and through each of these we show both positive and negative examples of how each of these components can unfold with their knock on effects.

We specifically draw attention to the temporal dimension. Typically, studies on virtual work focus on the temporal organization of collaborative work (Eisenberg & Krishnan, 2018; Jiao et al., 2016; O'Leary et al., 2014; Prasad et al., 2017; Wilson et al., 2008) rather than on the impact of time on virtual work itself. The team work literature suggests that time supports team members to perceive team processes and their peers' skills more accurately (Filho et al., 2014), and that time allows teams to achieve stability and psychological safety, especially when they're self-managed (Werder & Maedche, 2018). While our two cases are not as sensitive to temporal differences, time is influencing them in multiple ways: from being an essential component towards forming bonds (Team A), to time being a critical resource when calculating team productivity, negatively influencing team members' relationships and willingness to support each other (Team B). Equally, the equipment model evolves dynamically along the temporal dimension for Team A, whereas for Team B, changes in the equipment model are introduced in bursts following external interventions. We argue that virtual teams require time

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to become successful, because sharedness of mental models in and of itself is a process that takes time.

6. Conclusions

In this study, we presented a comparative case study of two small virtual teams of software developers with the aim to explore how virtual teams experience perceive proximity. In doing so, we unpacked the relationship between perceived proximity and shared team mental models. We join our voice with others (O'Leary et al., 2014; O'Leary & Cummings, 2007; Wilson et al., 2008, 2013) who called for a more focused investigation into the tension between physical and perceived proximity. While shared mental models have been particularly popular for studying the relationship between them and team processes and performance (Chou et al., 2008), to the authors' knowledge, they have not been considered as a potential theoretical explanation for perceived proximity. In addressing this gap, we provide a new way of thinking around quality communication and shared values among virtual teams, and draw attention to how work is organised.

Our contributions come with some limitations, which indicate steps for future research. Our findings cannot be generalised across all types of virtual teams. Our findings concern two small virtual teams without significant temporal differences time zone wise, and with varying degrees of virtuality (collocated as well as geographically distributed team members). As such, generalisation can solely take place where the spatial and temporal distribution and the degree of virtuality are similar. In addition, the two teams also consist of junior, mid and senior level software developers. It is reasonable to expect that a team formed by e.g., solely senior members may have more unified shared mental models (particularly the task model).

Our study was designed as a case study using GTM procedures. Combining GTM procedures with other research designs often limits the full potential of GTM (e.g., conducting theoretical

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sampling) and therefore, theory development (Wiesche et al., 2017). We would thus propose extending our findings first to theory, as is typical with studies using GTM techniques (Urquhart, 2016), which "can then be tested and validated in different contexts" (Davison & Martinsons, 2016, p. 247). As an indication, we would consider validating our findings with the help of teams of researchers and academics, who frequently collaborate with other researchers from afar using ICTs for the purposes of research projects and who assemble on a needs basis and are typically required to self-manage their work.

Another limitation stems from our empirical material and what this let us investigate. What we show in this study is that shared mental models facilitate communication and identification, having established the existence or absence of perceived proximity. Intuitively, we consider that communication and identification will reinforce each other and that a similar two-way relationship should exist between them and shared mental models. However, we were unable, on the basis of our empirical material to show such a mutual interaction, and we urge future researchers to look into this potential link further.

Finally, in this study, we focused on perceived proximity, which we did not unpack further. Boschma (2005) has indicated that there may be cognitive, organizational, social, cultural or institutional proximity, and Menzel (2015) argued that the interrelationship between these types of proximities can potentially explain how organisations bridge the objective distance, construct knowledge and innovate. As such, future research should focus on further refining our understanding along these lines. Along the same lines, existing literature suggests that there may be other factors that influence the quality of communication and identification, and in turn perceived proximity, such as dependability and accessibility (O'Leary et al., 2014); hence these could constitute areas for future research, too.

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9. Appendix

Table 7. Examples of Interview Questions

Overall Theme	Examples of Questions
Involvement in project	How did you get involved in this project? How long have you worked on this project? What is the size of your team? Please tell me about your role and tasks in the team. What roles do the team members have? How many features, modules etc have you developed so far? How did you manage to develop so many features? What did you learn from this experience?
Experience and Expertise	What is your background? How do you deal with new problems and opportunities? What have you learned from this project and collaboration? Explain how your technical knowledge was enhanced if at all.
Communication and coordination	What tools do you use? Can you tell us more about your collaboration with other stakeholders? How do you collaborate in your team? How would describe the cooperation between you? (attitude, smoothness, competition, priorities, knowledge sharing) How do you deal with uncertainty as a team? Can you remember a situation in your team in which you have experienced uncertainty? What led to this situation? How did this affect the project? How did this affect your work? What was the team's reaction? How often does a situation like this happen? How do you distribute effort among team members?
Relationship among members	How does the collaboration with project owner work out? What kind of relationships do you maintain among you, if any? Do you have an understanding of the team members' emotional state and worries? Who would you say is the team leader, if there is one? Do you feel included or excluded from the team? And from the team leader? What are the advantages and the disadvantages of this team and of this type of partnership?
Project management	Can you tell us more about the development of the current project? How did you design the development and the current project? The owner is using other information systems and applications as well. How did you design the necessary extensions/APIs to collaborate with these? What was his approach concerning the development of the project? What was the biggest challenge on this project and how did you achieve it? Do you think you have adequate resources for this project? If not, do you feel you can overcome this lack?

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Table 8. Examples of the coding procedure: categories, focused codes, initial codes

Category Code	**Focused Codes**	**Initial Codes**	**Examples from Interviews** (corroborated and enriched by observations)
Degrees of sharedness	Equipment Model	variety of ICTs, frequency of communications, quality of communications, choosing Skype over Slack, formalised communications, repository of information	"Every day I'm communicating with Bogdan, depending on what we're working on. I'll talk to other people in the office about, you know, specifically about things that we're working on. But yeah, I mean for me, I work directly with Bogdan every day, whereas everyone else it's an ad hoc" (Peter, Team B) "He will get the code, he will change it and he will send it back. We will then see the result on our browsers after few minutes, what he's done, has he fixed it. So we managed to reduced too much communication." (Dennis, Team A) "I sent him an email [to the Team Lead] so I know I have an email to show about this" (Peter, Team B) "We are using JIRA in a very convoluted way, not the proper way. So what we actually do is, for a specific project, for example, the [System1] project, we create a new project and then each of us we will create stories and for each story, there will be tasks. And those tasks will be given to developers and the stories give them the reason why these tasks have been initiated. And from there, they also know who has created each story, each task, when and how, so we can trace it back if needed." (Arjun, Team B) "We have a stand up, it's a small one, 5 to 10 minutes, ideally 5 minutes, then meeting, when each member of the team talks about what he has done yesterday and what he is going to do today. Also, if he has some concerns about his current tasks, he just notifies us. So just a heartbeat meeting about the situation of his team. Usually, I am working on software tasks because we have 3 hours difference between the Minsk office and the UK office right now. So I don't have to change. I can't communicate with a team because they're asleep." (Maxim, Team B)
	Task Model	Kanban board, coordination for tasks, tasks and task allocation	"Mainly through discussions, and allocations have to do with what each of us works with. Let's say, a task that has to do with the back end, I'd claim it, or Brian, or Dennis. (…) Or, somebody, not Dennis necessarily, may allocate a task to someone, based on their expertise." (Carl, Team A) "They tried to delegate this task to each other. (…) So the back end team tried to explain to our Belarus guys what is going on and that you should fix this task, it will be easier to fix this task on the front end side. But they explained it unclearly, in my opinion and in my Belarus colleagues' opinion." (Maxim, Team B) "Every team has set tasks that they are requested to do by the Product Team. So we use Jira to choose tickets. (Laura, Team B)
	Team Member Model	Different skills and competencies, shared values and beliefs, hobbies (incl. online gaming), team values, complementarities in expertise	"Depending on the problem we work in twos or threes. Many problems are solved by me or Dennis. Others are solved by Carl with Dennis, or Carl and myself. It depends on the feature, because not all of us have the same skills." (Al, Team A) "We have our issues, but they aren't so frequent. They haven't affected us much. There were instances we had to coordinate quickly, but our [family] priorities would put a hold to discussions, but such things happen." (Mike, Team A) "They can take that the plugin must only be developed for [system 1]. But when everyone said that, when that work is finished, then we move to [system 2]. The approach that they took to work on the plugin for

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			[system 1] didn't work. (…). They only focus on the task, they don't focus on the big picture (…). If this functionality works in [system 1], it needs to work on every [system].” (Arjun, Team B) “All the issues they are raising can be actually fixed if they speak to each other [i.e., other developers in Belarus]. So when it comes to [System 1], they don't have the ecosystem knowledge, they will be asking the exact same question that Maxim has asked me.” (Arjun, Team B)
	Team Interaction Model	Process in place, team-client communication, stand-up meetings, team structure, control	(on whether they have particular processes for collaboration) “Not really, it’s more on a needs basis, we’re online all day, for as long as necessary and we talk. We solve each other’s problems. That’s how we collaborate. There’s nothing to it. (Brian, Team A) “The Belarus team, their general methodologies are different to the Leicester team, but then obviously for those teams to communicate when they're working...” (Peter, Team B)
Shared dynamic and evolving understanding of tools	Adapting to needs	Integrating tools together, streamlining team processes, introducing automation	“We have to upload all of this to a server somewhere. (…) I have added this task in GitHub, but then, when it was time for deployment, we got TeamCity. We linked this to GitHub and every time we add new code in GitHub, it triggers TeamCity, TeamCity runs our code and publishes it to the server automatically. Before TeamCity, there were days with 30-40 commits, so imagine, one person maintaining the bit process and the deployment process on his own. Now it’s fully automated.” (Dennis, Team A) “For coordination, once I create a task, somebody will pick it up, they don’t have to communicate with each other too much about this.” (Dennis, Team A) “We wanted a tool to create tasks and be able to see whether a task has been completed or not and why. We wanted to connect this task with some part of our code that executes this task, so we chose Jira. So we integrated Jira to Slack. That is, every time a task is completed, it gets immediately published to our Jira channel and we can all see that somebody initiated a task, or when a task gets completed, we all see it”. (Dennis, Team A)
	Decision-making	‘a decision was made’, focusing on Product, deciding together, developers’ needs	“We [emphasis placed in ‘we’] decided on which tools to use. It’s not like there are many choices, four or five serious solutions. But we had to make it work, lightweight and all, and we decided what to use” (Mike, Team A) “The reason is that in Belarus the internet is really bad, there are times we can't talk to them. But through the phone is easy. Since we are [name of company redacted], we can actually call them cheaply. It's nearly free. (…) screen sharing and everything is really bad because of their internet connection and the infrastructure team, they are trying to improve that, but there is a lot of migration.” (Arjun, Team B) “A decision was made to move to MS Teams. We were always using Teams and Slack, but it was decided to move to Teams, it’s not really an improvement for us [developers], it’s for the benefit of other teams, like Product and Sales. Some clients still use Slack, so we will always be using both packages” (Peter, Team B)
Work Organisation	Management	Turnover, flat hierarchy, restructuring	“We don’t really have a manager. Our client is quite relaxed. He gives us plenty of time to meet our deadlines. But we do our work, we are not laid back, and he sees that and appreciates how complex the project really is and how difficult it is.” (Al, Team A) “Let’s say there is an informal hierarchy, Dennis is the face of the team. He gets in touch with clients. But that’s about it. He has no other privileges. Sometimes he coordinates us, but he is not our boss, the

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			Manager who would say “you haven’t finished this”. We are free to decide how much we will work, what we will implement.” (Brian, Team B) “The teams have changed a lot recently… People leaving, there's structural changes… The team that was originally part of [System1], the Team lead was moved out to be part of [System2], I was moved into a different team, because a new team was created and people were moved into there. There's been a lot of moving around.” (Laura, Team B)
	Development methodologies	Out-of-sync development, velocity, different Sprint cycles, pure Scrum, contextual knowledge of projects	“So basically, the Belarus team, their general methodologies are different to the Leicester team, but then obviously for those teams to communicate when they're working... let's say for instance, they've got team members that are local and then team members that are remote, they might have a hybrid methodology” (Peter, Team B) “So the junior developers, they don't actually know what this work is, what this ticket is. Some people ask but the thing is they have to be trained a lot. (…) you have to sit with them and train them (…). So that time is never invested in the development team. Since that time is not being invested, all the tasks that junior developers are doing, it's just gets blown out of our quota. So a simple task, a 5-point task, just blows up to be 13. So those kinds of stresses really impact the project delivery.” (Arjun, Team B)
	Temporal dimension	Time to bond, enough time within their team, time ‘outside’ work	“The teams have changed a lot recently… People leaving, there's structural changes… The team that was originally part of [System1], the Team lead was moved out to be part of [System2], I was moved into a different team, because a new team was created and people were moved into there. There's been a lot of moving around.” (Laura, Team B)

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Table 9. Klein's and Myers' guidelines for interpretive field research (Klein & Myers, 1999)

Principle	How the principle was applied in this study
Hermeneutic Circle	We observed and interviewed the two teams. From the interviews, we first identified the existence of absence of perceived proximity in the first instance, which was later confirmed through the interviews and the data analysis. The data analysis was conducted by both authors via discussion, were multiple iterations sharpened the focus of the analysis and of the resulting coding scheme. We cross-compared our codes across the two cases and within cases, and we shared our preliminary results with a key informant from Team A to clarify our interpretations and confirm the validity and plausibility.
Contextualization	We offer rich descriptions of the two teams (size, compositions, skills, roles), coupled with contextual information, which we use during our data analysis and the construction of our interpretations, in order to identify interactions between them.
Researcher-Subject Interaction	Due to the nature of the research design, there were both limitations and opportunities. We were able to observe extensively Team A and all the permanently remotely located members, but this was not the case for Team, with whom we had fewer opportunities for observations and we could not observe the permanently remotely located member. Our extensive engagement with Team A resulted in the researcher becoming a quasi-outsider/insider, who has occasionally consulted with regards to project management and client engagement, as she became to be a trusted person. While in the field with Team B this was not the case, where she clearly an outsider.
Abstraction and generalization	Our combined use of GTM procedures within a comparative two-case case study allowed us to draw comparisons between the two sites, and identify a relevant theory that could offer theoretical explanations for both sites (shared mental models). Because we only used a subset of GTM, however, generalization and development of a grounded-on-the-data theory, in the fashion of GTM theory was not possible, as theoretical sampling was not followed.
Dialogical reasoning	Our data analysis resulted in thick descriptions and qualifying what quality communication and identification with the team and their values may mean for the purposes of experiencing perceived proximity, through the lens of shared mental models. To do this, we frequently went back to our data set, core theories of virtual teams, team work and collaboration, and we revisited our coding scheme to make sure that our codes are mutually exclusive and representative, and that relationships among them are representative. While writing up our study, we revisited the relevant literature to make sure that our findings enrich existing knowledge on virtual teams and to address our main research question.
Multiple interpretations	For Team A we collected data from all involved. For Team B, we collected data from all team members. Ideally, we would have liked to include data from teams with whom Team B usually cooperates, and from the Product Team (however, this was not possible). We believe we have captured multiple viewpoints, and the large amount of data collected (observations and interviews) should reduce the chance of any biases distorting our data. With regards to examining competing theories, during our data analysis, we considered the use of the Sensemaking theory as introduced by Weick (2005); however, as an alternative explanation it did not prove to be able to support the 'sharedness' element that was coming across from Team A, i.e., couldn't plausibly explain our findings from both cases.
Suspicion	Being clearly external to the organization, we had no intention or motivation to introduce or influence the functionings of the two teams. The second author was critical during the data analysis and interpretation stage, acting as the devil's advocate and querying the validity of any assumptions.

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