RESEARCH ARTICLE

Crisis Readiness: Revisiting the Distance Framework During the COVID-19 Pandemic

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Abstract. While CSCW researchers have studied collaboration across distance for more than two decades, the scale and context of geographically distributed work during the pandemic is unprecedented. Working from home as the default setting during the COVID-19 pandemic provides a unique opportunity for CSCW research to explore and develop new understandings of what it entails to engage in distributed collaborative work during a global crisis. In this paper, we revisit the distance framework, originally developed by Olson and Olson in 2000, through empirical data collected during the critical moments where COVID-19 was declared a pandemic and the world shut down: namely March 2020. We use the data to interrogate the distance framework and to extend it with a new dimension - Crisis Readiness. Crisis Readiness stipulates that for organizations to successfully respond to crises, four factors are required: 1) the ability to respond fast with dramatic measures; 2) the ability to supply adequate infrastructure to their employees; 3) the ability to adapt work practice responding to new work and life conditions; and 4) the ability to handle multiple and diverse interruptions both at the individual and organizational levels. Our contribution to CSCW research is a revised distance framework, which demonstrates that for geographically distributed work to be successful during a global crisis, cooperating actors need to achieve Common Ground, engage in different types of coupled work, be ready for collaboration and collaboration technology – and lastly, work in an organization which demonstrates Crisis Readiness.

Keywords: Geographical distributed work, Crisis informatics, Crisis readiness, COVID-19, Distance framework

1 Introduction

In 2020, the COVID-19 pandemic had a widespread impact on people's personal and professional lives. Among the many measures taken worldwide to prevent infection and flatten the curve were recommendations and, at times, requirements to quarantine at home. This situation caused sudden disruptions to work, when entire organizations transitioned into dispersed work (i.e., physically alone with digital

communication (Braithwaite and Joyce, 2005; Sharp et al., 2012)) with little time to prepare in advance. During this period, many information workers transitioned to working from home, using technology such as shared documents and videoconferencing to communicate with co-workers. In lieu of their established and predominantly in-person work processes, millions of people started socially distancing through dispersed collaboration, replacing the transportation infrastructure with the digital infrastructure as the most critical infrastructure for collaborative work.

The field of CSCW has for decades studied distributed collaboration and the use of information technology to support such engagement (Olson and Olson, 2000; Bjørn et al., 2014; Bradner and Mark, 2002). In their seminal work "Distance Matters," Olson and Olson (2000) introduce the distance framework containing four dimensions of distributed work: Common Ground, Collaboration Readiness, Collaboration Technology Readiness, and Coupling of Work. They argue that for collaboration across distance to succeed the work arrangements require high Common Ground, appropriate levels of Collaboration Readiness and Collaboration Technology Readiness organized in a loosely coupled work setup across remote actors. Exploring the distance framework within Global Software Development one decade later Bjørn et al. (2014) found that in all the cases of successful collaboration, the work arrangement was organized in closely-coupled work, since only in cases where actors are forced through tightly-coupled work setups, the extra efforts of articulation work required for distributed collaboration will seem necessary. In this paper, we interrogate the distance framework with empirical data collected just as the COVID-19 pandemic closed down the world and transformed the work and life of millions of people worldwide in important ways. What makes the pandemic case unique for the theoretical study of distributed work is that it produced unique work situations, namely *socially distanced dispersed collaboration*.

The COVID-19 pandemic led to several sudden changes to society that also impacted how known dimensions of remote collaboration influence successful collaboration. For instance, research on distributed collaboration has traditionally studied contexts where teams are co-located (e.g., multiple offices in different countries (Herbsleb et al., 2000)); where only a subset of workers are at home (Greengard, 1995); or fully remote teams working in open-source projects (Yamauchi et al., 2000; Germonprez et al., 2018). In contrast, the need to adopt social distancing to prevent the spread of COVID-19 led to the emergence of dispersed teams for all - the place to work became the private homes of people – and all this happened in a matter of weeks or even days globally. In addition, there are several other widespread consequences of the pandemic that can impact those working from home, including economic stress, fear and anxiety of contracting COVID-19 and/or losing friends and relatives, and school closures creating additional work for parents (Machado et al., 2020). This additional work (e.g., childcare) severely impacted work, introducing different sets of interruptions associated with the situation when

work and life take place in the same environment (Ciolfi et al., 2020; Mark et al., 2016; Mark et al., 2008). In summary, working from home during a pandemic does not produce the same types of challenges as we know it from prior CSCW research in e.g., global software development (Bjørn et al., 2019). Thus, it is tremendously important that we explore and understand the specifics of working remotely from home during the pandemic from a CSCW perspective. Accordingly, the research questions we explore in this paper is are: RQ1: **To what extent does the distance framework account for crisis situations?** RQ2: **How can we extend the distance framework to include the specific challenges which arose during the COVID-19 pandemic?**

To answer this these questions, we report on empirical data collected between April and May 2020 during the early days of the COVID-19 pandemic in Brazil. We collected quantitative and qualitative data through a survey with 363 respondents working in over 40 cities in Brazil. We particularly focus on the period of transformation and how people adapted their collaborative work activities during the first month of social distancing. Based on analyses of both quantitative and qualitative data, we interrogate the distance framework (Olson & Olson, 2000), evaluating how each dimension is evident in the unique context of the pandemic. We also reflect on the different strategies and their impact on people's work in their response to the pandemic.

Based upon our analysis, we propose one additional dimension to the distance framework, namely Crisis Readiness. Crisis Readiness entails an organization's ability and performance in being able to function during unplanned and dramatic disruptive events which fundamentally changes the condition for work. Specifically, Crisis Readiness includes:

- The ability of the organization to respond fast with dramatic measures to crises;
- The ability of the organization to supply its collaborators adequate infrastructures: technical, social, physical, and psychological;
- The ability of collaborators to adapt work practices and processes responding to the new work, and life, conditions; and
- The ability of collaborators to handle multiple and diverse interruptions.

The rest of this paper is organized as follows. The next section introduces prior work on distributed collaboration in CSCW. This is followed by a description of our research methods, the data sources and materials, as well as how we analyzed the quantitative and qualitative data. Then, we present our results, which are followed by a discussion where we propose the dimension of Crisis Readiness and the associated implications of this dimension for future research on geographically distributed collaboration. Finally, we present our conclusions and suggestions for future work.

2 Background

2.1 **Working Across Geographical Locations**

Understanding the challenges of collaborating across geographical distances and designing technologies to support cooperative work activities for dispersed participants have been a core interest for CSCW research since its early days (Olson and Olson, 2000, 2013; Bjørn et al., 2014). Fundamentally, this body of work has strived to unpack the complexities which arise when two or more people are mutually engaged in a shared task and depend upon each other in order to solve this task (Schmidt , 2008). All CSCW work is a priori distributed (Schmidt and Bannon, 2013), as more than one person is involved, thus requires certain knowledge often embedded in artifacts to accomplish complex tasks – as have been pointed out by Hutchins in his canonical work on distributed cognition (Hutchins, 1995; Hollan et al., 2000).

Dispersed collaboration has been studied since the 1990's (Powell et al., 2004), as professionals in different locations gained access to internet connectivity. Over time, as computing evolved and broadband access increased, the challenges of effective dispersed collaboration also evolved (Bjørn et al., 2014). Different kinds of dispersed collaboration have been studied, from global virtual teams in large software companies (Sharp et al., 2012) to outsourced projects (Smite et al., 2014). Several factors such as trust, technology literacy, and cultural differences can affect efficiency and productivity among distributed workers (Edwards & Sridhar, 2003; Powell et al., 2004). These factors can change over time and they are different in specific contexts (e.g., working from home or an office) (Dix and Beale, 2012). In this paper we are interested in a type of distributed collaboration, namely collaboration without collocation as caused by the COVID-19 pandemic, forcing people to work from home in the context of social distancing.

We use the distance framework originally developed by Olson and Olson (2000), and further developed and extended by Bradner and Mark (2002), and Bjørn et al. (2014) as our starting point for the analysis of the cooperative work caused by COVID-19 in Brazil in March 2020. While the framework was not originally named, we refer to it as "distance framework" in accordance with prior publications (e.g., (Bjørn et al., 2014)). The original distance framework (Olson & Olson, 2000) fundamentally proposes four main dimensions that represent "the sociotechnical conditions required for effective distance work": *Common Ground; Collaboration Readiness; Collaborative Technology Readiness; and Coupling of Work*. Later on, a fifth dimension was added: *Organization Management* (Olson et al., 2008). We will visit each of these five dimensions in turn.

Common Ground refers to the ideal state arriving between cooperative partners engaging the grounding activities (Clark & Brennan, 1991). Grounding as a concept was originally developed from conversation analysis and referred to the activities and work involved when at least two actors exchange utterances and

interact concerning a shared task to reach mutual understanding. For example, someone states an utterance ('I have the papers in the bag') and there is a context by which to interpret the meaning of the utterance (the two actors sit at a table, where a red bag is placed), and the other actor confirms through feedback that both actors agree on the meaning of the utterance ('do you mean the red bag on the table'). Fundamentally, Common Ground is the state by which multiple actors share knowledge and know that they share knowledge (Olson and Olson, 2000). Common Ground has also been referred to as mutual knowledge (Cramton, 2001) or shared knowledge (Malhotra and Majchrzak, 2004). Establishing Common Ground has increased difficulties when collaborators do not have a shared meaning context (Bjørn and Ngwenyama, 2009), which places an important design challenge for cooperative technologies supporting geographically distributed teamwork. We expect Common Ground to be equally important for the COVID-19 remote work.

Collaboration Readiness refers to the ability of geographically distributed actors to be willing and able to collaborate on the shared task (Olson & Olson, 2000). Laboratory experiments have shown how people are less likely to collaborate if they believe they are physically far away from other actors and thus less likely to meet them in person (Bradner and Mark, 2002). Further results from ethnographic studies of outsourcing setups have shown the importance of trust and social capital risk (Boden et al., 2009; Søderberg et al., 2013) for Collaboration Readiness. Moreover, ethnographic research on global work demonstrates how unbalanced socioeconomic setups (Bjørn et al., 2019) which in essence seek to move work from the high salaries in the global north to lower salaries in the global south (Smite and van Solingen, 2015) risk hindering strong collaborative setups. Finally, implicit bias based upon negative stereotypes in global software development challenges the development of collaborative readiness (Matthiesen et al. , 2020). In the case of COVID-19, we expect those potential challenges to develop Collaboration Readiness are not related to the cultural differences nor socioeconomic differences, since neither of these was a driving factor for making people work remotely. However, we expect that the special situation of remote work from home will introduce new and additional aspects of Collaboration Readiness such as increased situations of interruptions (Gillie & Broadbent, 1989). Interruptions (self-made or structural) have been found to challenge productivity in the workplace (Brumby et al., 2019; Czerwinski et al., 2004; Mark et al., 2016), and we will consider how we can understand and account for these interruptions (O'Conaill and Frohlich, 1995) emerging from the mixed home/ work environment when exploring the COVID-19 situation.

Collaboration Technology Readiness refers to the state by which the collaborative actors are ready to use cooperative technologies to support their collaboration (Olson & Olson, 2000). In the early days of desktop-conferencing tools the extra work required to make the technology work was identified as a

core factor, and the argument was put forward that successful teams had identified a driver of the technology (Mark et al., 1999). Fundamentally, designing and implementing cooperative technologies into organizations often was problematic if these were not stable and reliable technologies (Esbensen et al., 2015), since the extra articulation work dedicated to technology use was perceived as problematic (Matthiesen et al., 2014; Boden et al., 2014). Cooperative technologies are not just a feature of the distance framework, but in essence, comprise the fundamental sociotechnical infrastructure (King, 2006) which enables geographically distributed work in the first place. Societal crises and information technology mutually impact each other; technology can impact crisis situations by e.g., augmenting or mitigating the crisis, and crisis situations can impact technology by e.g., limiting the availability of electricity (Eriksson and Pargman, 2018). When infrastructures simply function (like stable Internet, electricity, a video conferencing tool working smoothly, etc) they tend to blend into the background. Well-functioning infrastructures become invisible and taken for granted (Star, 1999). It is only upon breakdown (Hiltz et al., 2011; Semaan and Mark, 2012) that infrastructures emerge as pertinent for attention. It is only during breakdowns that infrastructures are available to scrutinize (Bowker and Star, 2000; Bjørn and Boulus-Rødje, 2018). When we explore collaborative technology readiness in the case of COVID-19, we will explore whether the existing dimension of Collaboration Technology Readiness captures the experienced challenges and consider how we can include considerations for infrastructures during the pandemic.

Coupling of Work refers to the work organization and work practice structure. The argument that Olson and Olson (2000) put forward is that for geographically distributed collaboration to be successful, the collaborative partners must have Common Ground, be ready to collaborate and use collaborative technologies – and enable low (i.e., loosely) coupled work. Low coupled work, they argue, allows for fewer dependencies which means that people are able to perform their work without needing too much coordination. Work can potentially be segregated (Gerson, 2008; Ackerman et al., 2007), reducing dependencies and delay (Herbsleb et al., 2000). However, despite dividing large tasks into smaller tasks making them easier to solve, the challenge of integrating e.g., smaller software tasks and dependencies requires recomposition (Grinter, 2003) and such integrating tasks without closely coupled interaction across teams despite geographical dislocation have been found to risk failing large software project (Matthiesen and Bjørn, 2015). Research within global software development demonstrated that closely coupled work forced distributed participants to spend the extra effort of articulation work required when people work remotely, and thus closely coupled work can be essential for successful collaboration (Bjørn et al., 2014; Jensen, 2014).

Finally, *Organization Management* involves managerial, structural, and legal aspects of work, and their compatibility with distributed collaboration, including incentives to facilitate remote collaboration (Olson and Olson, 2013). This aspect is important because if an organization does not recognize and reward collaboration, people are less likely to engage in collaborative behavior and adopt collaborative technologies (Orlikowski, 1992). When we explore Organization Management in the context of the COVID-19 pandemic, we will explore whether the incentives adopted by organizations were deemed appropriate by the workers. Our goal in this work is to extend the distance framework to include the specific challenges which arise during the COVID-19 pandemic.

2.2 The COVID-19 Pandemic Crisis

A *Crisis*, according to the Cambridge English Dictionary refers to a time of great disagreement, confusion, or suffering; a turning-point. In general, a crisis represents a process of transformation and may be caused by political events, labor strikes, or acts of nature, to name a few. Understanding crises can help organizations to "develop strategic plans" to deal with them (Hwang and Lichtenthal, 2000). The COVID-19 pandemic is a crisis and has enormously impacted how people live and interact with each other (e.g., social distancing, wearing masks, washing hands frequently, quarantining at home, etc.). Working from home is not a new reality for software development. Many companies adopt different levels of remote work such as having part of the team work remotely in a single country or having each employee working in their own time zone. Even before COVID-19, a few companies had no offices requiring all workers to work from home. For example, GitLab, with 1,200 employees in 67 countries (GitLab, 2020), has been a fully-remote-home workplace since 2014.

The COVID-19 pandemic led to a sudden increase in working from home worldwide. In the United States, those working remotely full time increased from 2% of the workforce to an estimated 40-50%, accounting for more than 23 of the US economy (Bloom, 2020; Brynjolfsson et al., 2020). This sudden shift in work location led to many challenges requiring that workers and organizations adapt to their new reality, such as introducing changes to planning (Ahmetoglu et al., 2021). This situation also impacted workers' wellbeing and productivity (Ford Robinson et al., 2020; Machado et al., 2020). Despite these challenges, researchers such as Barrero et al. (2021) have argued that remote work from home will remain common even after the COVID-19 pandemic.

Distributed collaboration is an essential part of addressing the challenges involved in a public health crisis. However, this context of great disruption is very different from the "normal" situations of distributed collaboration. What makes the COVID-19 pandemic a very special case for CSCW research is that the geographical distributed cooperative work which arrived from the remote work situation is 1) responding to an immediate crisis, and thus not planned; 2)

replacing the transportation infrastructures with digital internet-based infrastructures; 3) aggregating private and work spheres, thus introducing new types of disruptions. In this project, we aimed to understand these differences and find how the CSCW community can account for a crisis in distributed collaboration.

3 Methods

3.1 Context

This study was conducted at the beginning of the social distancing period in Brazil. The first case of COVID-19 reported in the city of São Paulo (Brazil) occurred on February 26, 2020, almost two months after the announcement of the outbreak of the disease in China (Heymann and Shindo, 2020). On March 20, 2020, the Brazilian government announced that community transmission of the new coronavirus (COVID-19) had been observed throughout Brazil (Brasil, 2020).

Brazil adopted different measures to contain the virus. Considering the large size of Brazil, different states went into lockdown or quarantine at different times. Thus, some states adopted different guidance and recommendations (e.g, from the World Health Organization). When we conducted the survey, state and local governments had started to implement preventive measures that led many office workers to work from home.

3.2 Data Collection

We investigated how companies and software engineers in Brazil adapted to dispersed work due to the COVID-19 pandemic and their experiences during this process. We used an online survey that collected data over a 5-week period between April and May of 2020. The respondents were recruited through posts on the authors' LinkedIn accounts and direct messages by email. We also asked informants to share the survey with other potential respondents in a snowballing process. We were not able to track the total number of individual people who saw the recruitment post.

All questions from our survey were phrased as comparisons between the period of remote work during the current pandemic and the period before the pandemic. An initial draft of the questions went through a pilot phase. Based on feedback from initial pilot participants, we revised the questions and launched the survey.

3.3 **Survey Design**

Our survey consisted of 31 questions ranging from demographics to specific questions designed according to the Olsons' framework. Each of these dimensions refers to the sociotechnical conditions required for effective remote collaborative work. Additionally, we included questions related to working from home during the unique period of the COVID-19 pandemic such as "infrastructure" to work from home, wellbeing (reported as one of the following states: anxious, calm, comfortable, uncomfortable, frustrated, worried, relaxed or any self-reported value), and interruptions. All questions were in Brazilian Portuguese.

Each one of Olsons' dimensions was mapped into two or more questions of our survey. We present them below.

3.3.1 **Common Ground**

Common Ground refers to the knowledge that people share and that they know they share with others (Clark and Brennan, 1991). To identify Common Ground in the data material, we collected data about how participants were able to mutually establish Common Ground through different types of conversations and resolving cases of divergence and convergence in concepts and meaning (Jensen and Bjørn, 2012). We specifically asked about success and failures to communicate and retain contextual information, in understanding and establishing Common Ground during dispersed work.

Questions in the survey about Common Ground included questions on the effort necessary to be understood by colleagues, as well as the effort necessary to handle a reduced sense of awareness. An example of a survey question, Q3, is presented below:

Q3 - While working remotely, the effort necessary to understand my co-workers: My efforts greatly increased; My efforts somewhat increased; My efforts did not increase nor decrease; My efforts somewhat decreased; My efforts greatly decreased.

3.3.2 **Coupling of Work**

Coupling of Work refers to the characteristics of the collaboration work itself, more specifically on the interdependence between cooperative engagements and sub-tasks divided across collaborators. Tightly coupled work is more interdependent, requiring more communication by the participants to mediate, coordinate, and align their individual yet cooperative activities—namely, articulation work (Schmidt, 2008).

In our survey, we included both closed- and open-ended questions about Coupling of Work. These questions were used to study the distributed collaboration factors that emerged during social distancing. For instance, we asked about

whether the numbers of high-dependence tasks increased, decreased, or remained the same. In an optional follow-up open-ended question, participants were asked to explain their responses.

Q9 - Please answer the following questions comparing your work before and after the social distancing period. While working remotely, the number of high-dependence tasks I am responsible for: The number of high-dependence tasks decreased, increased, no change?

Q10 - Could you explain the answer to the previous question?

3.3.3 Collaboration Readiness

Collaboration Readiness is concerned with how motivated remote partners are to engage in collaboration activities together, proactive communication, trust, and commitment (Søderberg et al., 2013).

The survey investigated Collaboration Readiness by prompting participants to indicate how engaged, motivated, available, and proactive their co-workers were while working remotely even in an adversarial situation (e.g., addressing conflicts).

Q11 - While working remotely, select your degree of agreement with each of the following sentences: My co-workers show motivation for remote work; My co-workers show engagement with others; My co-workers show a disposition to foster a positive work environment; My co-workers show enough availability to answer questions; My co-workers show productivity in professional collaboration.

3.3.4 Collaboration Technology Readiness

The Collaboration Technology Readiness dimension was measured in the survey by asking about the effective use of existing technology infrastructure (robust bandwidth for video calls, stable internet connection) to support in all remote work environments to accomplish needed tasks.

For this dimension, we included a closed-answer question on infrastructure or technology challenges during remote work with only *yes* or *no* responses, and an open-ended question was asked to explain their response only if participants selected *yes*.

Q17 - Did you encounter infrastructure or technology challenges (internet connection, mobile connection, equipment, hardware, etc) to use the new technologies (question 12) that your organization adopted for remote work? *(Yes / No)*

Q18 - Please describe the infrastructure or technology challenges or the new technologies (question 12) that your organization adopted for remote work.

3.3.5 Organization Management

Organization Management refers to decision-making processes, organizational policies, and managerial issues (norms, incentives, procedures) supporting

collaboration across distance (Olson and Olson, 2013). For Organization Management, we analyzed the adaptation of strategies, tools, routines as well as the challenges faced by dispersed teams while managing projects.

In this case, the question in the survey about Organization Management was mapped to a list of strategies and incentives offered by organizations during the pandemic (e.g., change in the frequency of meetings, flexible working hours, funding for home-office infrastructure, etc) so that participants could select the ones adopted by their organizations and even include new ones.

We classified all organization actions that came up in the data into three categories:

- Incentives: breaks, bonuses, gifts, opportunities for informal socialization virtually (e.g., synchronous coffee break);
- Tangible: infrastructure, electronic equipment, furniture; and
- Intangible: changes in working hours and management (e.g., flexible hours, meeting schedules, performance expectation, and evaluation), psychological support (wellbeing surveys, health status, telemedicine, therapies, and supervision);

The last open-ended question asked for additional comments about challenges that participants faced or were facing, both professionally and personally to manage during remote work.

Q30 - Do you have any additional comments about this survey? Was there anything that deserves attention but has not been asked? For example, are there other challenges that you have or are facing, both professionally and personally to manage your remote work? Have you had any additional support from your organization? Please write about anything you consider important. Challenge examples: changes in work rhythm, reorganizing your home, childcare or other caregiving, etc. Support examples: mental health resources paid by the company, etc.

3.3.6 Interruptions

Finally, in our survey, we asked about the duration and frequency of interruptions in two questions using a five-point Likert scale for the responses. We introduced the concept of interruption in our survey because we were interested in understanding how participants experienced interruptions of their dispersed collaborative work during the period of social distancing.

We decided to explore the impact of interruptions because previous work has shown that interruptions have a severe impact on productivity (Mark et al., 2016; Mark et al., 2008) and are particularly relevant when work and personal life take place in the same physical environment (Ciolfi et al., 2020).

By interruption, we mean something that intentionally stops a task (e.g. a phone call, an instant message, children talking, an alarm that goes off, etc) (Mark et al., 2016). Interruptions are not necessarily detrimental to work. For instance, Mark et al. (2008) argue that the effects of interruptions from the same context of the current task can be *beneficial*, whereas interruptions from a different context can be disruptive and negatively impact the task being performed.

The following are the questions about interruptions that participants were asked:

Q7 - While working remotely, regarding the number of interruptions to your work. The number of interruptions decreased, increased, or did not change?

Q8 - While working remotely, regarding the length of interruptions to your work. The length of interruptions decreased, increased, or did not change?

The full version of the survey in English is available at the following link: github.com/clarac/distancesurvey/wiki.

3.4 **Quantitative Data Analysis**

We received a total of 401 responses, and 366 of them were determined to be valid. Removed data either did not meet the study criteria (i.e., dispersed work during social distancing) or were repeated data from the same individual. Among the respondents, 164 were women, 197 were men and 5 did not specify a gender. Their ages ranged from 20 to 66 (median=36). Most participants (*N*=245) had technology-related job titles (e.g., software engineer, product manager), while other jobs included bank analyst, government prosecutor, research professor, etc.

To validate the indicators and dimensions of Olsons' distance framework, the structural equation modeling approach was used, applying partial least squares (PLS-SEM), using the SmartPLS software. PLS-SEM is a "flexible" technique capable of estimating complex models, being commonly used in exploratory research for the development of theory, receiving an important emphasis in studies with data from social sciences and humanities (Hair et al., 2019).

The application of PLS-SEM allowed the validation of the distance framework as a second-order formative-reflective construct (Hair Jr et al., 2020). Second-order constructs are established by agglutination of first-order, conceptually and theoretically complementary latent variables. In this perspective, the main construct – the distance framework – is a formative construct, and its dimensions are reflective constructs. A formative latent construct is "caused" by its indicators, and a change in the latent construct is not necessarily accompanied by a change in all its indicators. On the other hand, a reflective latent variable is composed of indicators considered influenced, affected, or caused by the underlying latent variable (Hair Jr et al., 2020). The PLS-SEM approach followed the recommendations of (Hair Jr et al., 2020; Sarstedt et al., 2019), for the specification, estimation, and validation of second-order constructs, through composite confirmatory analysis.

The second-order construct for the distance framework was built using PLS graph. This method can be used as a tool for theory confirmation and it can highlight relationships between variables. As first-order constructs, we included the five known dimensions of the distance framework: Common Ground, Collaboration Readiness, Collaboration Technology Readiness, Coupling of Work, and Organization Management. We also added a sixth first-order construct: interruptions, since earlier results showed that this was an influential factor for collaboration.

3.5 Qualitative Data Analysis

We obtained qualitative data from each of the open-ended questions in the survey. We used coding procedures from Grounded Theory (Strauss and Corbin, 1994) to analyze these data.

We started this analysis with open coding, where three authors independently read and coded the data. In addition to these initial codes, each open-ended response for Q10 (referring to Coupling of Work) was labeled based on the answers to Q9. With this information, we were able to categorize the data into three groups: respondents whose coupling increased, decreased, or did not change. During the analysis process, the comparisons between these three groups were noted and discussed.

We iterated on and refined the initial codes during synchronous meetings by discussing conceptualizations and combining similar codes to arrive at a unified code book. Then, the data were recoded using the code book and higher-level themes were extracted during analysis. The first author wrote memos based on these themes. The memos were then shared with all authors and updated through synchronous discussion. The data were analyzed in Portuguese, but the quotes included in this paper were freely translated to English.

4 Quantitative Findings

Table 1 shows the factor loadings and t values of the six first-order constructs (the distance framework dimensions augmented with the concept of interruptions) in the measurement model. Meanwhile, Table 2 summarizes the measures of validation of these same first-order constructs: means, standard deviations, average variance extracted (AVE), composite reliability levels (CR), and construct correlations. Overall, the results indicated very satisfactory measurement properties. All loads were significant ($p<0.05$) and higher than 0.6 (Bagozzi and Yi, 1988). The AVE scores (>0.5) and CR levels (>0.7) for each construct corroborated the evidence of convergent validity (Hair Jr et al., 2020). To verify discriminant validity, the correlations between constructs were compared to their AVE. In each case, the square root of the AVE exceeded the correlation between the constructs,

Table 1 Measurement Model Loadings

textbfConstruct / Statement	Loadings	β
Collaboration Readiness (1 – Strongly Disagree to 5 – Strongly Agree)		0.556**
My co-workers show motivation for remote work	0.747**	
My co-workers show engagement with other	0.837**	
My co-workers show disposition to foster a positive work environment	0.860**	
My co-workers show enough availability to answer questions	0.736**	
My co-workers show productivity in professional collaboration	0.838**	
Collaboration Technology Readiness (1 – Increased a Lot to 5 – Decreased a Lot)		0.288**
Difficulty of using the new technologies that your organization adopted for remote work	0.784	
Time needed to accomplish your work using the new technologies that your organization adopted for remote work	0.861	
Effort needed to use the new technologies that your organization adopted for remote work	0.867	
Common Ground (1 – Increased a Lot to 5 – Decreased a Lot)		0.442**
While working remotely, the effort necessary to understand my co-workers	0.845	
While working remotely, the effort necessary to make myself understood by my co-workers	0.841	
While working remotely, the effort necessary to plan and distribute tasks with my co-workers	0.744	
While working remotely, the effort necessary to resolve conflicts or disagreements with my co-workers	0.762	
Lack of Interruption (1 – Increased a Lot to 5 – Decreased a Lot)		0.194**
While working remotely, the number of interruptions to your work	0.962**	
While working remotely, the length of interruptions to your work	0.954**	
Organization Management		0.050*
Sum of organization incentives adopted to facilitate remote work	0.672*	
Sum of team incentives adopted to facilitate remote work	0.948**	
Loosely Coupled Work (1 – Increased a Lot to 5 – Decreased a Lot)		0.060**
While working remotely, the number of high-dependence tasks I am responsible for	1.000**	

* $p < 0,05$, ** $p < 0,01$

Table 2 Scale Validation Measures

	Mean	SD	CR	AVE	1	2	3	5	6	7
Collaboration Readiness	3.93	0.76	0.90	0.65	**0.81**					
Collaboration Technology Readiness	2.97	0.69	0.88	0.70	0.106	**0.84**				
Common Ground	2.49	0.66	0.88	0.64	0.228	0.372	**0.80**			
Lack of Interruption	3.04	1.37	0.96	0.92	0.115	0.283	0.209	**0.96**		
Organization Management	1.05	0.97	0.80	0.68	0.113	0.112	0.022	0.035	**0.82**	
Loosely Coupled Work	2.89	0.87	-	-	0.071	0.154	0.166	0.170	0.016	-

SD – standard deviation; *CR* – composite reliability; *AVE* – average variance extracted; Diagonal elements in bold are the square root of the AVE

providing evidence of discriminating validity (Fornell and Larcker, 1981). Also, the heterotrait-monotrait (HTMT) values of the correlations, all below 0.9, indicated the discriminating validity of these six first-order constructs (Hair Jr et al., 2020).

As mentioned in Section 3.4, the distance framework was defined as a reflective-formative construct, whereas lower-order constructs are different from each other and not interchangeable (Jarvis et al., 2003). Unfortunately, quantitative traditional methods to access construct validity and reliability are not appropriate for formative constructs (Diamantopoulos & Winklhofer, 2001). We thus followed recommendations from (Sarstedt et al., 2019) to verify the distance framework as a valid reflective-formative higher-order construct. First, we checked for collinearity issues among the lower-order components: the estimated variance inflation factors (VIF) for Collaboration Readiness (1.074), Collaboration Technology Readiness (1.244), Common Ground (1.237), lack of interruption (1.123), loosely coupled work (1.055), and organization management (1.025), were lower than the conservative threshold of 3 (Hair et al., 2013). Second, we considered the relationships between the higher-order component and its lower-order constructs (see Fig. 1A). Four of them were significant and relevant (Collaboration Readiness: β =0.556, p<0.01; Collaboration Technology Readiness: β =0,288, p<0.001; Common Ground: β =0.442, p<0.01; lack of interruption: β =0.194, p<0.01), but two were not relevant although significant (organization management: β =0.050, p<0.050; loosely coupled work: β =0.060, p<0.01). Therefore, we concluded that two dimensions - organization management and loosely coupled work – would not compose the second-order construct of the distance framework in the context of the COVID-19 pandemic.

We then verified a nested model without the two dimensions – organization management and loosely coupled work. The regression coefficients of the retained first-order constructs on the second-order construct distance framework remained significant and relevant (Figure 1B): Collaboration Readiness: β =0.574, p<0.01; Collaboration Technology Readiness: β =0.289, p<0.001; Common Ground: β =0.452, p<0.01; and, finally, lack of interruption: β =0.194,
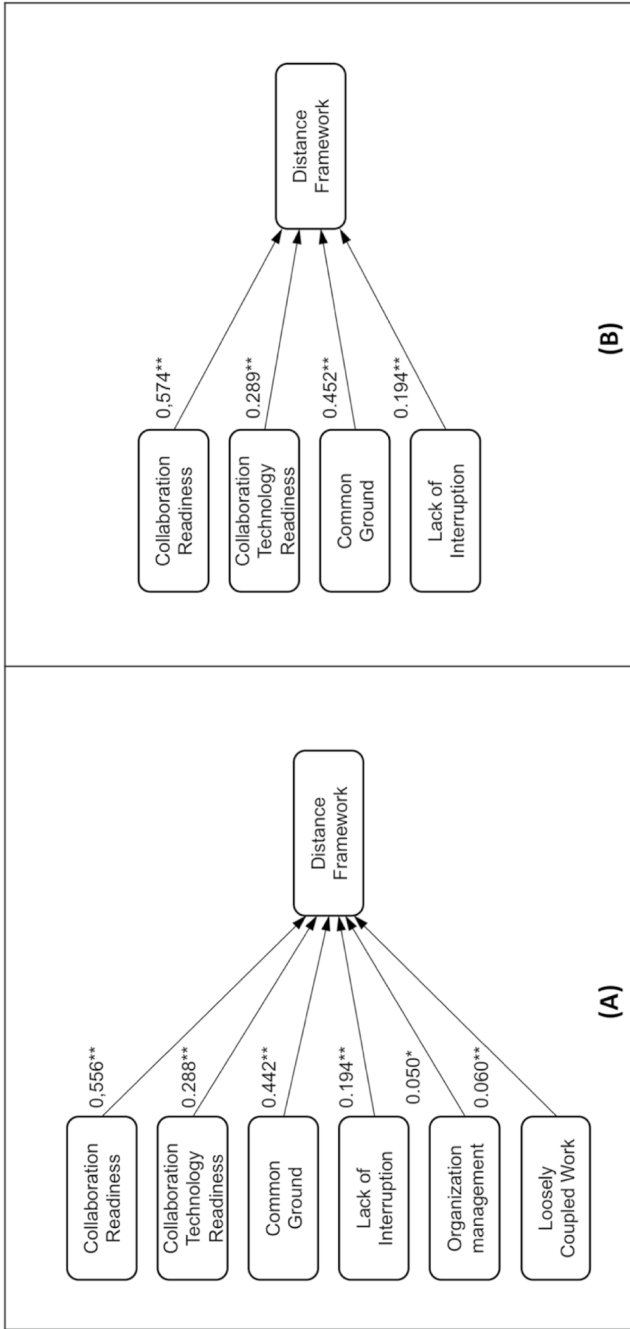
Fig. 1 The distance framework in the context of the COVID-19 pandemic. Diagram (**A**) shows PLS-SEM coefficients for each construct, all of them are statistically significant. Diagram (**B**) does not include constructs with low relevance (β <0.1)

p<0.01. Also, the VIF for these first-order constructs were lower than the conservative threshold of 3. Hence, we can conclude that, in our dataset collected at the beginning of the COVID-19 pandemic, the second-order construct distance framework was validated and composed by the following four dimensions: (i) Collaboration Readiness, (ii) Collaboration Technology Readiness, (iii) Common Ground, and (iv) lack of interruption. In the next section, we describe qualitative results that further explain this result.

5 Qualitative Findings

Results from our quantitative analysis suggest that two constructs - Organization Management and loosely coupled work - would not compose the second-order construct of the distance framework in the context of dispersed work during social distancing. In addition, the construct lack of interruption, which was not in Olson and Olson's original distance framework, was deemed significant and relevant. Through a qualitative analysis of open-ended responses, we were able to better understand these results. Accordingly, in this section, we describe qualitative findings around three constructs: Coupling of Work, Organization Management, and interruptions.

5.1 Coupling of Work

Tightly coupled work is challenging to accomplish remotely, as reported by the vast majority of our respondents. This was a shared result by those who experienced changes to coupling at the start of the social distancing period and those who did not. However, this challenge was one among several factors involved in the decisions to alter coupling or not. While most participants reported no change in coupling, other informants said that their work became either substantially more tightly coupled or more loosely coupled. In the rest of this section, we describe the several factors that influenced Coupling of Work for each one of these groups of participants: whose tightly coupled work remained stable, increased, or decreased.

5.1.1 No Change in Coupling

The majority of participants did not report a change in coupling. There were three distinct reasons for the lack of change: the work was already loosely coupled, the work was already remote, or there was no change in workflow other than substituting in-person interactions with virtual communication.

Those whose work was already loosely coupled expressed that there was *no need* for a change in their tasks, since they could work independently. For

instance, P268, an IT analyst reported: "Regardless of the social isolation, the tasks I work on barely require communication with co-workers."

Similarly, those whose work was already done fully or partially remotely reported that there was little change for them after the social distancing period started. For instance, P286 said that he and his team "were already used to working with remote teams and therefore there was little change for us." - P286 (34, data scientist). In short, those who already conducted their work remotely before the social distancing period felt less of a need to adapt their workflow or collaboration with others to the new circumstances.

The last group of respondents who reported no change in coupling described that their tasks remained very similar to what their work looked like *before* the pandemic. The only substantial change was the substitution of in-person interactions with virtual tools - e.g., video calls. For example, P38 described that adapting to remote work consisted simply of adopting virtual alternatives to in-person meetings: "There was no need to change our work processes for remote work. We went from in-person meetings to calls." - P38 (32, software developer). It was not clear from the data why this group did not find the need to make changes to coupling. A possible explanation is that we collected our data a couple of weeks after the social distancing period started, so perhaps the informants have not had the chance to adapt their work practices. We will revisit this in the Discussion section.

5.1.2 More Loosely Coupled

There was another group of respondents whose work became *more* loosely coupled in response to the pandemic. There were 3 distinct approaches in this case: reducing coupling on purpose, prioritizing loosely coupled tasks, and reducing communication to avoid bothering others.

Several participants had their work purposefully planned to be more loosely coupled to reduce any potential negative impacts on work performance. These decisions were explained as deliberate initiatives to mitigate the challenges of remote collaboration. P101 succinctly explained how "due to [social] distancing there was a need for extreme autonomy, keeping productivity in mind." - P101 (40, systems analyst). Meanwhile, P13 described how the reduction in tightly coupled work was accomplished through changes in management strategies: "Management has become more detailed, there is less need to actively work together with the rest of the team." - P13 (27, software analyst). Further, P278 specified that work tasks were revisited with the purpose of reducing coupling: "The tasks that might require [tight coupling] have been reworked to be accomplished individually." - P278 (31, software engineer). As these quotes show, many respondents actively changed their work, in agreement with their superiors, to reduce the challenges involved in tightly coupled work.

Another approach to reduce work coupling involved changing the priority of tasks. That way, the more tightly coupled tasks are delayed to when the workers return to "normal" office work. This was the case for P187, as she explained: "My manager and I decided to re-prioritize my tasks so that I would work on tasks that depend less on interactions with others on my team. We believe that this way I could keep my focus and motivation even during the pandemic." - P187 (38, product manager). This strategy would likely only be effective in the short term, as these data were collected during the first weeks of the social distancing period that lasted for several months.

A third group of participants whose work became more loosely coupled described how co-workers themselves took the initiative to communicate less with others, e.g., by trying to solve problems on their own instead of asking someone for help or to ask for feedback on their work. For instance, P253 said that he and his team limited communication to the most essential situations: "We ask questions only when it is unavoidable, when it was not possible to solve the problem [through other means]." - P253 (27, automation engineer). Managers also reported a similar change in the behavior of co-workers, due to getting less questions from them.

These purposeful reductions in coupling could be due to the inherent limitations in remote communications, such as how they tend to be asynchronous and take more time. P195 explained that slow communication causes delays in her own tasks: "there are situations where another team takes a long time to respond and only then can I continue my work" - P195 (39, Project manager). These data show that there was a general perception that remote communication was more burdensome for both parties, and this perception led workers to reduce them.

5.1.3 More Tightly Coupled

Among those who reported that their work became more tightly coupled, the change in coupling was described as inevitable. There were a few different reasons for the reported need to increase coupling, namely (i) the additional work required to transition into remote work, (ii) changes in the nature of work due to the social distancing period (e.g., interacting with clients virtually instead of face to face), (iii) a consequence of the need to maintain Common Ground through more burdensome communication means, and (iv) making up for the loss of visibility to others when working remotely.

In general, respondents did not display a perception that tight coupling is more advantageous in remote work. On the contrary, these respondents often highlighted that the increase in coupling was challenging. Still, it was seen and reported as necessary. For example, several managers reported an increase in structure and details when assigning tasks to their teams, in order to reduce misunderstandings and need for communication later on. "I manage a team of 36 people (Software Development Team). If the team experiences any

challenges in their tasks, I need to support them. Since the challenges have increased, dependence [coupling] has increased." - P234 (46, manager of a software team).

For other respondents, the very nature of their work was impacted due to the transition to working from home. These impacts created a need for updated processes, additional work, and training. For instance, P120 explained: "I had a client-facing role at a bank. Now I work through the bank's chat and I constantly have to ask [someone else] if I can perform the task that the client requested through chat." - P120 (34, bank clerk).

Several participants described an increase in work coupling (as a proxy for increase in communication) that was necessary to achieve or maintain Common Ground during dispersed work. The increased time spent in virtual meetings to accomplish the same tasks was described as an increase in coupling - because the limitations in communication while remote created a need for increasing *formal* communication (e.g., meetings). For instance, P168 explained that there was an increase in virtual meetings in lieu of communication that used to happen informally in the office: "Every time we have [tightly coupled] tasks I need to have video calls. Previously, it was enough to turn around and chat." - P168 (27, technical consultant).

The examples above highlight how the loss of face-to-face and informal communication, such as hallway conversations, makes tightly coupled work more challenging. Here, the increase in coupling is not caused in changes in the tasks themselves. Rather, there is an increased need to communicate because of the limitations of the communication channels available.

Beyond synchronous meetings, informal communication could be substituted for asynchronous communication such as email and instant messaging. Participants expressed frustration with these channels, as explained by P33 in the following quote: "Now that we need to communicate through chat tools, there are people who ignore [requests] more easily and there is no way to know if they actually are busy. It always [happens] when the client is waiting for an answer!" - P33 (27, implementation analyst). A major limitation of asynchronous communication is how the interactions take longer, and the period of waiting can be frustrating and cause delays in tasks.

We also found that there were cases where coupling increased to make up for another limitation of the collaboration during social distancing, namely the lack of visibility of the workers' activities. In fact, there was additional work for the purpose of surveillance as to increase visibility and accountability in comparison with in-person work. For example, respondents described facing an expectation that others will be online and quickly responsive during work hours, or overworking to avoid a negative perception from others that they are slacking off. P184 explained that this increase in work, often a decision of an individual, impacted other co-workers and caused strain in collaboration: "People have a need to prove

that they are working and as a result they ask much more from others than they would normally." - P184 (32, designer).

In a few cases, respondents described that this effort to increase visibility - often through more work - was driven by economic stress. There was a fear of losing the job and an initiative to help the organization stay afloat during the economic crisis taking place alongside the pandemic. That was the case for P146, as shown in the next quote: "Everybody is making an effort to maintain productivity at the same level as in the office or even higher, to help get through the crisis. This effort requires the involvement of several teams into new projects and to maintain the operation afloat. A challenge exists to create engagement and synergy throughout the company." - P146 (38, IT infrastructure analyst) In this case, increasing workload/coupling was a mechanism to protect the workers themselves against adverse events. The increase in coupling was a consequence of a larger workload overall, driven by several factors.

5.2 **Organization Management**

Our participants reported a diverse set of actions adopted by their organizations to address the challenges of dispersed work during social distancing. While the quantitative variable used in the models is based on the number of actions adopted by respondents' organizations, through the qualitative analysis we were able to obtain more information about participants' perceptions around these actions, how effective they considered them to be, and what actions they believed were necessary but had not been implemented during the pandemic.

In general, most respondents believed that the actions taken by their organization were beneficial. In a few cases, respondents said that these actions were enough, as shown on this quote: "The company delivered to my house all resources needed so that I can work comfortably." - P229 (48, software developer). Other participants acknowledged specific challenges they faced, while expressing that their organizations took the actions necessary to address these challenges. For example, P234 discussed network bandwidth problems that impacted workers for a few days: "Since the entire team started working remotely, we have had to double our internet connection bandwidth and that took around 3 days. In these 3 days we dealt with slow connections and outages. However, afterwards everything has gone back to normal." - P234 (46, manager in computing).

Still, many respondents said that the actions taken by their organizations were insufficient, citing specific examples of issues they were experiencing that could be addressed by these organizations. For instance, P155 highlighted the need for providing infrastructure and managing performance expectations, implying that her organization missed the mark on these issues: "Companies should concern themselves with moving furniture and equipment needed for remote work. They should also keep in mind that this period requires adaptation instead of pressure

for deliverables and results." - P155 (29, manager). Similarly, P244 described that his organization did provide minimum resources for dispersed work, but nothing beyond that - and that workers needed to actively ask for resources such as ergonomic chairs:"The company did not offer any additional infrastructure support (beyond the basics: VPN and bringing our computer home). There was an offer of ergonomic chairs in response to complaints." - P244 (47, researcher). Similarly to P244, other respondents expressed a need or wish for more support from their organizations, without however specifying what they wanted or needed.

Many participants described exactly what was lacking from their organizations in response to the pandemic. Often these wishes were related to resources needed because of the change to dispersed work (e.g., help with VPN access). As an example, P220 wished for more technology support during the transition to remote work: "The company could make available a phone number for IT support to help us with questions or problems in remote access." - P220 (43, bank analyst). In addition, several respondents reported a need for psychological support to address the impact of the pandemic, and wished that their companies would have supported them by providing access to resources such as a therapist, either directly through the company or through other means (e.g., health insurance). This was the case for P183, who mentioned that the COVID-19 pandemic caused economic anxiety for many people: "the main issue is that this is not normal remote work, it was forced and with no prior planning. There is a lot of anxiety and fear of unemployment because of the coronavirus." - P183 (33, systems analyst).

On the other hand, P187 expressed gratefulness for the actions taken by his organization acknowledging the practical and psychological challenges that the workers may be facing, such as reduced work hours: "I think I am lucky to work at a company that has a very humane approach. I know the company is being very understanding of the workers who have kids and who need to reduce their working hours to share childcare responsibilities with their spouses. [...] my manager and I talk not only about my tasks and whether I need help with them, but also about how my personal life is going, how I am dealing with the quarantine, etc." - P187 (38, product manager). This kind of organizational support described by P187 was very rare among our respondents. In a few cases, people even highlighted that the initiatives (or lack of) taken by their organization caused them to have additional stress, such as refusing to transition into remote work until they were legally required to do it. For instance, P33 expressed frustration that preventative measures were only taken when legally required, leaving the workers potentially exposed to the virus: "We did not get any psychological support, the director himself made it clear that he did not believe in the danger! We only started working remotely because of a state decree!" - P33 (27, software developer).

Organization management measures that were perceived negatively always involved either an increase in workload and stress or surveillance policies. For instance, surveillance-oriented initiatives such as creating a daily detailed report of activities, became a burden for workers.

P140 explained that the lower visibility of working hours led to more tasks and higher output expectancy: "the workload has increased greatly. For two reasons: 1) there was a request for daily report of activities, which in practice became another daily task; 2) the pressure for delivering results has increased. I believe that both are consequences of a 'fear' that the workers are not actually doing their work." - P140 (29, systems analyst). Additionally, a few respondents such as P244 described that dispersed work creates challenges to take breaks, particularly with the increase in workload. "Difficulty to limit work hours. I have worked much more, because I cannot separate work and rest time appropriately. We have more meetings and progress reports." - P244 (47, specialist researcher). These issues illustrate negative consequences of organization management measures. While such measures have their reasons, such as making up for the lack of awareness and visibility in the workplace, they also brought negative consequences.

Overall our respondents reported mixed feelings about organization management. Several measures adopted by organizations are beneficial, but not enough. A few measures seem negatively could create need for others (e.g., psychological support). Our results also suggest that organizations handled the pandemic at different ends of the spectrum: some increased a pressure for results while others reduced performance expectations.

5.3 Interruptions

While the quantitative results did not differentiate between home interruptions (e.g., from a child) and work interruptions (e.g., from co-workers), we were able to look at them separately in the qualitative analysis. We discuss each group below.

As expected, the interruptions experienced at home generally increased for participants overall, even for those with prior remote work experience, as other members of the household were also present. Respondents discussed their responsibilities that led to these interruptions, including childcare and house chores. Time-specific chores such as cooking meals were particularly mentioned as difficult to reconcile with work. For instance, P209 explained that having a child at home who requires attention leads to several interruptions: "The biggest challenge is my son not going to school and requiring attention. Interrupting focused work to answer my child creates additional effort to get back to my thought process." - P209 (42, government prosecutor). Sharing resources at home was also mentioned as a source of interruption. Several participants, such as P123, did not have enough infrastructure at home for everyone to work remotely: "the COVID pandemic is different [from normal remote work]; having to share the same room

and computer with everyone [in the house] and handle tasks that were not needed previously." - P123 (39, systems analyst). Interruptions from family members living in the same household also took more direct forms, including noise and a lack of respect for quiet work time, as P268 explained: "personal issues can interfere during a video-conference. For example, noise, a family member calling, a dog." - P268 (29, IT analyst) There was a common complaint about others in the same household who did not behave as if the person were working, such as expecting that respondents would be available for chatting or free to help with a house chore during work hours: "Difficulty for people in my house to understand that I am working." - P253 (27, automation engineer).

On the other hand, changes in interruptions from co-workers varied across respondents. Several participants described an increase in these interruptions, while several others reported a decrease.

Those who experienced an increase in interruptions mentioned that these were due to expectations of constant availability and a need for frequent communication to reach Common Ground with co-workers. P77, for instance, described a large number of calls from co-workers "What is bothersome are the excessive calls and unnecessary interruptions." - P77 (29, systems analyst).

Those who described a decrease in these interruptions discussed how there is less chatting with co-workers during focused work, as they only interact when required. In these cases, as P94 explained, respondents often described an increase in productivity: "My productivity somewhat increased, since I can stay focused and since I usually spend days to finish a task, I don't need to have too many meetings, and that helps a lot. In the office I had lots of interruptions." - P94 (35, senior software developer).

In summary, our results suggest that management of interruptions (including work-related events and family or home circumstances) in an unprecedented period during COVID-19 pandemic is clearly revealed as an important factor upon work boundaries and traditional notions of work life.

6 Discussion: Crisis Readiness

The distance framework stipulates that the best conditions for successful collaboration across geographical distance entail situations where there is a high Common Ground, loosely Coupled Work, high Collaboration Readiness, and high Collaboration Technology Readiness, and Organization Management that supports dispersed collaboration (Olson and Olson, 2000, 2013). Further, situations of closely-coupled work in dispersed work arrangements force people to frequently engage in the extra efforts of articulation work which is required for successful collaboration (Jensen, 2014; Bjørn et al., 2014). Finally, organizations need to be supportive of collaboration across geographical distances. In our study, we found that all these original features of distributed work were evident
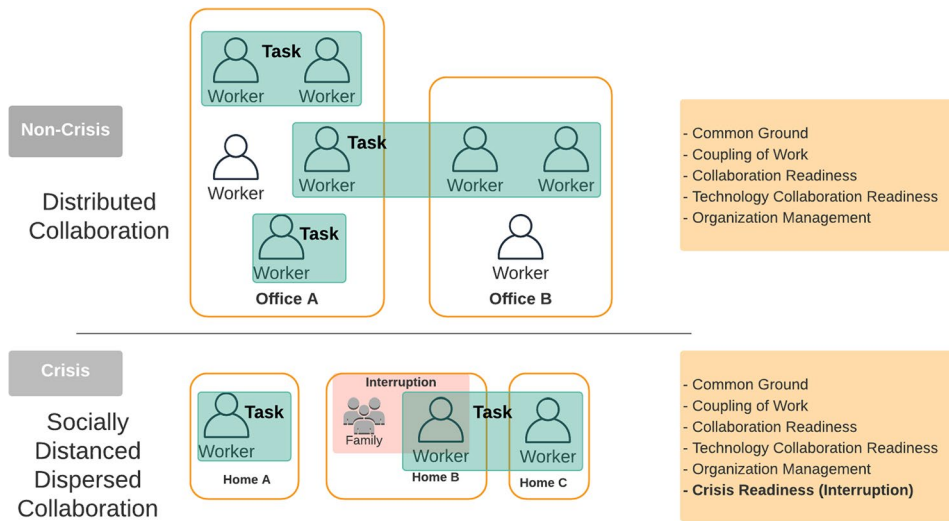
Fig. 2 Non-crisis vs. crisis collaborative work

in our data material. However, we also interestingly found that disruptions displayed core characteristics that shaped the ways in which dispersed collaboration during the COVID-19 pandemic took place. The disruptions experienced during the COVID-19 crisis impacted workers in many ways and affected the ways in which the original dimensions (Common Ground, Collaboration Readiness, Collaboration Technology Readiness, Organization Management, and Coupling of Work) in the distance framework were experienced and manifested in their work. Disruptions fundamentally challenge the taken-for-granted assumptions about work, thus making visible what is needed and required when working from home during a pandemic. Disruptions took different forms and while some were of a social nature (e.g. disruption due to childcare while working at home) others were technical of nature (e.g., disruption due to lack of stable Internet at home). However, all the different sociotechnical disruptions together made visible the fundamental sociotechnical infrastructure (Star, 1999; Bjørn and Boulus-Rødje, 2018) required during social distancing to reduce the effects of the pandemic.

Further, our results suggest that several characteristics of the dispersed work caused by the COVID-19 societal crisis that impacted the remote collaboration cannot be modeled solely under the five dimensions of the original distance framework. This result is expected since this framework was initially designed to be used under non-crisis situations. To account for these additional characteristics we, in this section, introduce Crisis Readiness, a new dimension for the framework that can inform future crisis responses and advance preparation.

Crisis Readiness refers to organizations' and workers' abilities to effectively adapt and respond to the disruptions caused by a crisis that fundamentally

changes the cooperative work conditions. Preparing and responding to a crisis as an organization is not a new topic, as several scholars outside CSCW research have studied this issue. Organizational Crisis Readiness (or preparedness) is a term coined by Reilly (1993) that was initially defined as organizational flexibility in times of uncertainty caused by a crisis. Many authors argue that crisis preparation may be a critical determinant of survival for any organization, as it is an inevitable part of the organization and cannot be separated from regular business activity (Quarantelli, 1988; Hickman and Crandall, 1997; Labaš et al., 2017).

Figure 2 illustrates the differences between the distance framework prior to the pandemic vs. during the pandemic crisis situation. While in the former, the focus is mostly on office work, in the latter all work has been brought home during social distancing with important consequences introducing sociotechnical disruptions. While work across different geographical locations exists in both situations, dispersed work while social distancing introduces additional challenges, which organizations must account for – and should prepare for in the future. Figure 2 includes simplified examples of collaborative work that might take place in each context, such as collaboration between workers in different offices and interruption in the home affecting collaboration between dispersed workers.

The widespread use of CSCW tools during the COVID-19 pandemic (especially video calls, but also shared documents and instant messaging) emphasizes what prior research on crisis has demonstrated earlier (Eriksson and Pargman, 2018), namely that technology and crisis are interconnected and co-constituted. Technology can mitigate or augment a crisis, while a crisis can impact technology by e.g., limiting Internet access. Organizations must understand the important interconnection between CSCW settings during crisis situations to be able to consider the existence of work practices that are based on collaboration between stakeholders, co-workers, business partners, customers, etc, which will be seriously impacted if a crisis should emerge. While information and communication technologies were widely adopted to address challenges related to the crisis (e.g., collaborating while socially distancing), this rapid and unplanned adoption created new challenges and needs for people adopting these technologies.

Crisis research has much in common with CSCW research (Pipek et al., 2014), as it involves collaboration among individuals, organizations, and communities – and we have witnessed how crisis informatics scenarios such as the use of Twitter during hurricanes have been the topic of CSCW research. Crisis Informatics takes an interdisciplinary perspective on the sociotechnical, informational and collaborative aspects of crisis preparedness (Pipek et al., 2014). Still, there are important differences between local crises (as in hurricanes, earthquakes, etc) and global crises as the COVID-19 pandemic. In other words, *the empirical instantiation of the Crisis Readiness arriving from the COVID-19 pandemic in the distance framework allows CSCW new ways to integrate crisis research.*

The Crisis Readiness dimension encompasses the experience of organizations and workers during the COVID-19 pandemic. We argue that awareness of Crisis Readiness can help both workers and organizations to learn from the COVID-19 pandemic and better prepare for collaborative work in the context of future disruptions. Specifically, in this study, we identified the following four elements of Crisis Readiness:

- The ability to respond fast with dramatic measures to crisis situations.
- The ability to adapt work practices and processes responding to the new conditions.
- The ability to build adequate technical, social, physical, and psychological infrastructure.
- The ability to handle multiple and diverse interruptions.

We discuss each of these elements individually in detail in the sections below.

6.1 The Ability to Respond Fast with Dramatic Measures to Crisis Situations

Our study was conducted at the beginning of the COVID-19 social distancing period. For this reason, the challenges described here reflect the initial process of transitioning to dispersed work from home. These challenges are substantial, particularly because there was not much time to prepare for this transition in advance. This sudden change impacted Coupling of Work as teams were required to adapt their processes, workflow, communication, and overall tasks to be accomplished completely remotely – sometimes overnight. As shown through our findings, such transformations require additional closely-coupled work, as individuals are required to communicate with one another while developing and establishing new communication norms and expectations. Further, much effort is required by organizational members to request clarifications about how pre-existing tasks should be accomplished using different tools in the new crisis setting.

We also found challenges related to awareness and availability expectations. The lack of an established process to monitor work beyond attendance and in-person observation (e.g., seeing the person typing at their desk) led many organizations to find a need for alternative awareness strategies. These actions often led to increased workload and stress, whether they were self-initiated, subtle, or official policies. The negative experiences were, at least partially, caused by the sudden change to dispersed work limiting the amount of time available to study and consider potentially better options. Still, substituting the subtle awareness strategies produced by physical collocation with technology-mediated strategies was experienced as a complex issue that warrants more academic research (Heikkilä et al., 2018; Ball, 2010; Stark et al., 2020). Previous CSCW awareness research (Bardram and Hansen, 2010; Gross, 2013; Gutwin and Greenberg, 2002) offer excellent foundations for creating new viable design approaches to

solve the immediate awareness issues which emerged during the COVID-19 crisis; however new research is needed to figure this out and moreover, such new designs must recognize the important balance between privacy and awareness in CSCW (Ackerman, 2000).

The unclear duration of the social isolation period also created a vacuum for making drastic decisions. The continuous assumption that the pandemic would only be temporary made it difficult to develop long-term strategies. Then, when the duration of the pandemic kept growing, short-term strategies were deemed problematic. Strategies had to be updated over time as the dispersed work period was extended to last over 1 year. It would be worthwhile to study how these strategies changed over time.

The additional work involved in adapting to changes in work processes as well as the changes in the nature of work itself led to an increased workload, as workers still needed to execute their regular responsibilities. This additional articulation work became problematic since participants "need access to appropriate means of communication" to articulate these new work arrangements (Schmidt, 2008). Having processes in place that facilitate quick adaptations could benefit both workers and organizations. In this study, those who already had experience with remote work, even if only part-time, faced fewer challenges with the transition. For this reason, establishing norms, processes, and infrastructure for remote work (including considering working from home) could help increase Crisis Readiness for organizations.

6.2 The Ability to Adapt Work Practices and Processes Responding to the New Conditions

In our dataset, the measures taken to adapt work practices were related to either Organization Management (e.g., changes in working hours) or Coupling of Work. Organization Management decisions were taken by organization representatives (e.g., human resources) or managers, while decisions to change Coupling of Work were taken both by workers and managers.

While in our quantitative analysis we measured Organization Management based on the number of actions taken, our qualitative data suggest that the impact of those actions varies widely, with certain actions causing increased stress and workload. Organization management strategies also contribute to workers' well-being as some participants reported being "lucky" because they worked for organizations with a "humane" approach. Further, many participants highlighted that actions were lacking in some organizations, particularly in terms of helping workers cope with the disruptions caused by the crisis to their professional and personal lives.

Changes in Coupling of Work tasks, while important, are not straightforward decisions. Impacts might depend on context. Overall, known challenges to successfully accomplishing tightly coupled work are still at play, as remote

communication is more effortful (Neale et al., 2004; Olson and Teasley, 1996). Still, tightly coupled distributed work often cannot be avoided in a crisis, i.e., if all work is distributed as teams became fully dispersed, any tightly coupled work necessarily will be distributed. Additionally, disruptions caused by the crisis might create a need for more tightly coupled tasks, such as changes in work and workload due to factors such as moving from an in-person to a virtual client-facing role or increased demand for help from co-workers. On the other hand, organizations and workers might work to reduce tightly coupled work in response to a crisis.

While efforts to make work more loosely coupled due to the change to socially isolated dispersed work were reported in the data, it only happened in rare cases. It is to some extent unavoidable that fully dispersed teams collaborate remotely in tightly coupled work unless all tasks can be segregated. If there are no co-located teams (Neale et al., 2004), organizations must find ways to solve tightly coupled tasks remotely. In addition, coupling of work involves trade-offs in dispersed teams, it might vary over time and differ for different workers. For example, planning and guidance tasks can become more tightly coupled (e.g., more detailed) for a manager to reduce coupling for the other members of the team (who work more independently). This example suggests that during a crisis some actors might need to perform extra work to allow other actors to be more independent (Matthiesen et al., 2014), therefore incentive or reward structures supporting cooperation must be put in place (Grudin, 1988).

6.3 The Ability to Build Adequate Technical, Social, Physical, and Psychological Infrastructure

Several of the challenges identified in this study were directly related to how dispersed work during a crisis required additional sociotechnical infrastructure (Mazel-Cabasse, 2018). Such need for infrastructure was physical (e.g., quiet workspace), technical (e.g., adequate network bandwidth), social (e.g., mismatched expectations of family members), and psychological (e.g., coping with economic anxiety).

To address the technical needs, the transition to socially-distance dispersed teams required workers (to create or adapt a workspace at home) and organizations (to provide equipment for remote work and handle a sudden increase in remote access) to engage in infrastructuring activities shaping the new situation. This need for additional technical infrastructure illustrates the relationship between Collaboration Technology Readiness and Crisis Readiness. Before COVID-19, research reported that Collaboration Technology Readiness had become less of an issue compared to 2000 as the technology had evolved and issues such as technology literacy and internet connectivity gradually improved within organizations (Bjørn et al., 2014). However, a sudden change from working primarily at offices to widespread working from home expanded the scope

of Collaboration Technology Readiness as the technical infrastructure had to be extended from workplaces to workers' homes. In other words, while organizations have largely become highly technologically ready for distributed collaboration, they were not ready for fully dispersed teams before the COVID-19 crisis. In this context, Crisis Readiness accounts for this context-specific need for technical infrastructure.

Additionally, we found that psychological resilience and pressure due to economic anxiety, fear of losing jobs, or managerial surveillance were important factors for workers during this period. That is, these aspects are additional infrastructures that organizations and workers need to consider in the context of socially distanced dispersed collaboration. In short, the COVID-19 crisis introduced numerous disruptions to work that were not associated with any of the five dimensions of the original distance collaboration framework (e.g., economic stress, limited childcare services, lack of subtle in-site work surveillance).

While previous CSCW research of crises (e.g., hurricanes and earthquakes (Palen et al., 2010)) have shown that such crises risk causing major breakdowns in technological infrastructures (e.g., electricity or water); the case of COVID-19 was different. The COVID-19 crisis did not directly disrupt infrastructures on electricity or water, instead, it disrupted the information structures (Star and Ruhleder, 1996) associated with "normal" office work by extending the range and need of these infrastructures. For example, issues such as network bandwidth, which had been addressed by organizations prior to COVID-19, re-emerged as important issues that had to be addressed by workers and organizations in new ways. Similarly, the lack of subtle on-site work surveillance created, in some cases, additional effort and pressure for dispersed workers.

6.4 The Ability to Handle Multiple and Diverse Interruptions

There were many challenges observed in this study that were very clearly related to the specific context of the pandemic. While their impact on work and collaboration was substantial, it is unlikely that they would be present under different circumstances. Examples include the unavailability of services such as childcare, schools, restaurants, and the need to manage work and family responsibilities at the same time.

In this paper, we use the concept of interruptions as a way to take these issues into account. We did not investigate in our quantitative data whether interruptions were associated with the number of kids and people living in the household. However, in our qualitative data, we could identify how interruptions often were reported as emerging due to family members who were also quarantining at home, specifically children. Further, we found that interruptions were related to the transformation of work (e.g., to ask for orientations), surveillance, or increased workload due to economic anxiety.

Mark et al. (2008) argue that the effects of interruptions depend upon the contextual nature of the interruption. They found that interruptions related to the context by which the participant is currently involved (same context situation) could be beneficial; while interruptions related to a different context than the current one are often disruptive. During the COVID-19 pandemic, private and work contexts merged since all work had to be done from home without different types of home support (e.g., childcare, schools), which resulted in a complex and relational work-life boundary (Ciolfi et al., 2020). Fundamentally, such setup risks providing an increased number of different-context interruptions (from work to private life and vice versa) increasing the experiences of disrupted work and private life. This suggests that most interruptions in the home were negative to the task at hand, and that home and family life also risked being highly disrupted during the socially distancing period.

In Fig. 2, interruptions are illustrated as a part of Crisis Readiness. The quantitative results show that interruptions were significant and impactful characteristics of socially distanced dispersed collaborative work. Thus, we propose to make interruptions part of what constitutes a collaborative context in a crisis. However, interruption is not a complete or precise measure of Crisis Readiness, since interruptions might be beneficial to remote collaboration (e.g., to build common ground or rapport), specifically if interruptions were characterized as same-context interruptions. Still, some of the crisis-related problems which emerged during COVID-19 were caused by interruptions or other issues such as infrastructural breakdowns and inaccessibility (Bjørn and Boulus-Rødje, 2018; Jabbar and Bjørn, 2018; Langhoff et al., 2018).

The role of interruptions during the pandemic adds additional complications to collaborations. Interruptions must be expected and considered as part of the organizational preparedness and Crisis Readiness. We speculate that interruptions might be evident during future global crises other than COVID-19; such as a global crisis caused by the current climate crisis. Thus, we argue that organizations must identify new strategies to organize work and infrastructures preparing for disruptive work situations constituted by remote and hybrid work arrangements in the future.

7 Conclusion

In this paper, we proposed Crisis Readiness as a dimension in the distance framework (Olson and Olson, 2000, 2013; Olson et al., 2008; Bjørn et al., 2014). Crisis Readiness entails an organization's ability to prepare and deal with a disruptive situation that fundamentally transforms the conditions for work due to an immediate crisis. We contribute to CSCW by empirically evaluating the distance framework with quantitative data. We hope that our methodology provides a starting point for others in pursuing research

on geographically distributed work using the distance framework as a foundation. Secondly, we extend the distance framework with a new dimension: Crisis Readiness – based upon collected data from the unique situation of the COVID-19 crisis and cooperative work during quarantine. We emphasize how interruptions and dramatic changes in sociotechnical infrastructures transform the work context impacting both work and private life.

The original distance Framework (Olson and Olson, 2000) was created based on the experience of Olson and Olson studying distributed collaborative teams. Future research should investigate how the concept of Crisis Readiness can be used to explain how organizations and actors deal with collaboration in dispersed teams, i.e., whether this concept can explain success or failure in collaborative endeavors. Additionally, investigating long-term impacts of dispersed work during COVID-19 would contribute to our understanding of factors impacting Crisis Readiness. For example, the measures taken to adapt to collaborative work during social distancing likely led to an increase in Collaboration Technology Readiness, creating more opportunities for distributed collaboration.

Declarations

Conflicts of interest The authors declared that they have no conflict of interest.

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