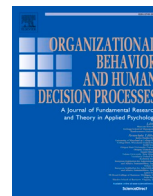




Contents lists available at ScienceDirect

Organizational Behavior and Human Decision Processes

journal homepage: www.elsevier.com/locate/obhdp

Hidden costs of text-based electronic communication on complex reasoning tasks: Motivation maintenance and impaired downstream performance

Ravi S. Gajendran^a, Jeffrey Loewenstein^b, Hyeran Choi^{c,*}, Sibel Ozgen^d

^a College of Business, Florida International University, Modesto A. Maidique Campus, 11200 S.W. 8th St, MANGO 472, Miami, FL 33199, USA

^b Gies College of Business, University of Illinois at Urbana-Champaign, 350 Wohlers Hall, 1206 South Sixth Street, Champaign, IL 61820, USA

^c D. Abbott Turner College of Business, Columbus State University, Synovus Center for Commerce & Technology 338, USA

^d School of Business, Stevens Institute of Technology, Hoboken, NJ 07030, USA

ARTICLE INFO

Keywords:

Virtual work

Remote work

Text-based computer-mediated communication

Media synchronicity theory

Conservation of resources theory

Motivation maintenance

ABSTRACT

The popularity of remote work and a norm of constant connectivity have made text-based computer-mediated communication (tCMC) such as email inevitable for many organizational tasks. This could be worsening communicators' performance on their later work. Specifically, drawing on media synchronicity theory (Dennis & Valacich, 1999), we propose that using tCMC for convergence processes—resolving ambiguity and conflicting interpretations to form shared understandings—is more difficult than using face-to-face communication. We use conservation of resources (COR) theory to argue this greater communication difficulty could dampen motivation maintenance for subsequent tasks, which, in turn, is likely to hamper knowledge work tasks that require complex reasoning. Supporting this line of reasoning, four experimental studies show causal effects of using tCMC (relative to in-person interaction) for tasks dependent on convergence processes on motivation maintenance and later complex reasoning tasks. A fifth study using an experience sampling design shows day-to-day changes in tCMC use influence depletion and downstream motivation maintenance for individuals whose jobs require complex problem solving. Together, these five studies indicate using text-based communication media has lasting effects on communicators beyond the communication task itself. These studies raise new questions about the pervasive use of email and other forms of text-based communication in organizations for individuals' motivation and effectiveness.

Communication technologies have changed how people get work done in organizations, yet we do not fully understand how those changes affect the people doing the work. There could be hidden costs to employees from their communication media choices. This would be a crucial issue given organizations' increasing reliance on spatially and temporally dispersed modes of organizing, such as remote work and virtual teams, let alone the pervasive use of electronic communication among collocated employees (Barley, Meyerson, & Grodal, 2011; Raghuram, Gibbs, Hill, & Maruping, 2019). Although computer-mediated communication (CMC) can occur through video and audio channels (e.g., Skype, Zoom, FaceTime), text-based electronic communication (tCMC) such as email and chat are important conduits for organizational communication (Tankovska, 2021). Indeed, employees spend about a quarter of their day on email exchanging about 100 messages (Abramovich, 2019; Chui et al., 2012; McGregor, 2012;

Radicati & Hoang, 2011). The COVID-19 pandemic-induced remote work has only increased employees' reliance on tCMC, including email (Kun et al., 2020). Those employees are not just using tCMC to convey factual information, but also for converging on shared understandings in the course of collaborative knowledge work (Fayard & Metiu, 2014; Gibson, Gibbs, Stanko, Tesluk & Cohen, 2011; Hinds, Liu, & Lyon, 2011; Rockmann & Northcraft, 2008; Tangirala & Alge, 2006). The question is, at what cost to communicators.

This question arises due to theory and research showing tCMC, while apt for conveying factual information, is ill-suited for resolving ambiguity (Daft & Lengel, 1984). Specifically, media synchronicity theory (Dennis, Fuller, & Valacich, 2008; Dennis & Valacich, 1999) conceptualizes communication as consisting of conveyance and convergence processes. Conveyance processes involve senders transmitting information to receivers, so receivers can process the information and update their

* Corresponding author.

E-mail addresses: rgajendr@fiu.edu (R.S. Gajendran), jloew@illinois.edu (J. Loewenstein), choichoi_hyeran2@columbusstate.edu (H. Choi), dr.sibelozgen@gmail.com (S. Ozgen).

<https://doi.org/10.1016/j.obhdp.2022.104130>

Received 9 May 2020; Received in revised form 25 January 2022; Accepted 1 February 2022

Available online 21 February 2022

0749-5978/Published by Elsevier Inc.

understandings. Convergence processes involve senders and receivers engaging in the collaborative resolution of ambiguity and differences in perspective¹. Convergence processes are crucial for collaborative knowledge work (Daft & Lengel, 1984; Dennis et al., 2008; Dennis & Valacich, 1999). A central prediction of media synchronicity theory is that tCMC media, such as email, are ill-suited for convergence processes because tCMC media limit informational cues, making it difficult for communicators to resolve the ambiguities inherent in many organizational tasks (Hightower & Sayeed, 1995, 1996; Kock, 2004; McGrath & Hollingshead, 1994; Swaab, Galinsky, Medvec & Diermeier, 2012; Wiesenfeld, Raghuram, & Garud 1999). Accordingly, the theorizing predicts that using tCMC for tasks heavily reliant on convergence processes imposes costs on the task for which communication is taking place.

Shifting attention away from the task to the people doing the task reveals a further key implication of using tCMC for convergence processes. If using tCMC for convergence processes is difficult, it likely imposes costs on the people using it. If so, the costs could extend beyond the task at hand to affect what those people do on other tasks. This is no small matter, as it implies that tCMC use could impose costs not just for the fraction of the day when employees are on email and so forth, but also for the remainder of their day, including when they are not communicating at all.

Some emerging research is consistent with the possibility tCMC imposes costs on people. For instance, research highlighting the downsides of pervasive electronic communication in organizations has found that higher levels of email use are associated with higher stress levels (Barley et al, 2011; Mazmanian, Orlikowski, & Yates, 2013), as well as lower work goal progress and diminished leadership (Rosen et al., 2019). Likewise, higher evening smartphone use for work-related communication, which is largely text-based in nature, is associated with lower work engagement the following day (Lanaj, Johnson, & Barnes, 2014). This research on stress, burn-out, and work engagement due to the always on culture of connectedness is important in emphasizing the costs of the sheer volume and pervasiveness of tCMC. A key next step is to generate evidence of direct causal effects of tCMC use for convergence processes on people and their subsequent behavior after they are done communicating.

The mechanism explored here to link using tCMC for convergence processes with reduced performance on subsequent tasks is motivation maintenance. Motivation maintenance is concerned with sustaining effort over time across a set of tasks and refers to “the degree to which individuals continue to invest time and energy in their work” (Grant et al., 2007, p.54). Motivation maintenance matters because it is often instrumental in not settling for heuristic responses and instead engaging in the complex reasoning needed to make effective decisions (Weber & Johnson, 2009). Complex reasoning, and so motivation maintenance, is foundational for effectively performing the cognitively intensive organizational tasks required for knowledge work. Diminishing motivation maintenance then provides a basis by which tCMC use for convergence processes can affect communicators and thereby impair their subsequent work.

If tCMC use for convergence processes impairs subsequent knowledge work, after people are done communicating, it would represent a critical cost of contemporary work practices imposed on employees. It would indicate a set of practices for organizations to understand and manage. Identifying motivation maintenance as a mechanism through which tCMC affects people after communication ends can enrich theorizing about tCMC’s associations with stress and work engagement (Grant et al., 2007). As the volume of tCMC grows, fueled by remote work and a culture of constant connectivity (Mazmanian, 2013), the

cumulative effects of tCMC on motivation maintenance could contribute to reduced productivity, increased stress, and lower work engagement. Thus, establishing causal effects of what using tCMC does to communicators, beyond what it does to immediate task performance, helps to solidify the link between communication media use and employee energy and effort in organizations (Grant et al., 2007; Lilius, 2012; Quinn, Spreitzer, & Lam, 2012). The ubiquity of virtual work and tasks requiring convergence processes means that tCMC such as email and instant messaging could well be a hidden drag on group and organizational productivity when misapplied.

1. Background and hypotheses

Text-based communication is commonplace and central to knowledge work due to tools such as email, chat, Slack, and Microsoft Teams used daily on a variety of devices by hundreds of millions of people for (Spataro, 2021; Mazmanian, 2013; Mazmanian et al., 2013; Reyt & Wiesenfeld, 2015). While tCMC is useful for some aspects of knowledge work, it is less suitable for more complex types of knowledge work activities. For instance, multiple theories have argued tCMC is well suited for sharing information (Daft & Lengel, 1986; Dennis & Valacich, 1999). In particular, media synchronicity theory (Dennis et al., 2008; Dennis & Valacich, 1999) proposes that tCMC is particularly well suited for conveyance processing intensive tasks, which are primarily concerned with the exchange of new and relevant information in a diverse set of formats that enable communicators to revise their understandings. For instance, sending an email memo summarizing the latest market segment trends with the relevant data reported in an Excel spreadsheet attachment would be an instance of conveyance processing. Sending new information imposes requirements on receivers to examine it, which is why conveyance processing is facilitated by lower synchronicity communication media such as tCMC.

Theorizing about communication media also argues that there are tasks for which tCMC are less well suited. Media synchronicity theory (Dennis et al., 2008) proposes that tCMC is less suitable for organizational tasks that are largely dependent on convergence processing, or for simplicity what we refer to as *convergence processing tasks*. These are communication tasks characterized by ambiguity and differences in perspective requiring communicators to generate a shared understanding of the situation. Common examples of convergence processing tasks are negotiation, coordination, and group decision-making. Convergence processing tasks differ from conveyance processing tasks in that what is central is not information transmission but collectively interpreting already shared information to generate common understandings. Plentiful research finds that when tCMC is used for tasks mainly reliant on convergence processes, such as collaborative knowledge work, it hampers communication effectiveness (e.g., Alge, Wiethoff, & Klein, 2003, Canessa & Riolo, 2006) and reduce task performance (e.g., Baltes, Dickson, Sherman, Bauer, & LaGanke, 2002; Bordia, 1997; Swaab et al., 2012).

Despite the theoretical and empirical work indicating tCMC is not well suited for convergence processing tasks, it is nonetheless commonly used for them. Nearly all virtual work arrangements require convergence processes as members engage in collaborative knowledge work (Alavi & Leidner, 2001) to coordinate their beliefs and behavior (Okhuysen & Bechky, 2009) as they pursue organizational goals (Cramton, 2001; Fayard & Metiu, 2014; Hinds et al., 2011; Wiesenfeld et al., 1999). Thus, if tCMC is ill-suited to convergence processing tasks, it would be consequential.

1.1. Using tCMC for convergence processing tasks and communication difficulty

The foundation of the problem of using tCMC for convergence processing tasks is communication difficulty (Cramton, 2001; Hightower & Sayeed, 1995). The lack of social context cues in tCMC places demands

¹ Given this description, we emphasize that tasks involving “convergence processing” as conceptualized by media synchronicity theory differ from tasks involving “convergent thinking” as conceptualized in creativity research, which are concerned with deriving correct or best responses (e.g., Cropley, 2006).

on crafting messages and disambiguating messages. This is because there is little in the way of context or feedback, such as non-verbal and paraverbal cues (McGrath & Hollingshead, 1994), to indicate and coordinate the common understandings that are the joint product of conversation. Further, tCMC limits the use of most turn-taking and back-channel coordination mechanisms, such as head-nodding, smiling, “uh-huh” and other such means for immediately signaling understanding and misunderstanding (Clark, 1996), which support staying together in the same type of dialogue (cf., Levin & Moore, 1977; McGinn & Keros, 2002; Yates & Orlikowski, 1992). The absence of support for feedback and multiple cues in tCMC is likely to increase the challenge of forming shared interpretations of ambiguous situations.

Media synchronicity theory (Dennis et al., 2008) synthesizes these insights. A medium’s synchronicity refers to the extent to which its capabilities enable communicators to “exhibit a shared pattern of coordinated synchronous behavior with a common focus” (p. 581). Face-to-face communication typically facilitates higher synchronicity among communicators while tCMC is associated with lower synchronicity. Although media synchronicity theory describes several such capabilities, two are particularly relevant when it comes to understanding tCMC use for convergence processing tasks—transmission velocity and symbol sets. Transmission velocity refers to the extent to which a communication medium enables rapid back and forth communications without delay. High transmission velocity allows communicators to efficiently share and contextualize their interpretations of ambiguous task situations, quickly seek and receive clarifications and repair misunderstandings, and verify the extent to which they share common understandings of situations. All these supports for convergence processing are theorized to be more difficult and take longer to accomplish using tCMC because of the lags tCMC introduces between communications. Creating communications and then sending them after they are completed takes longer and is less sensitive to feedback during the formation of those communications than delivering those communications as they are formed.

Symbol sets refer to the extent to which a medium supports a wide variety of communication formats such as verbal and nonverbal cues, visual information, and physical gestures. Face-to-face communication supports a variety of symbol sets whereas tCMC is limited to text-based cues. Being limited to one channel for communication means typing a message generally involves greater cognitive effort than speaking, as written communications encourage greater precision and higher levels of detail to promote clarity and minimize misunderstandings. These concerns are especially relevant for convergence processing tasks. In contrast, because in-person conversations allow for the real time communication of a range of verbal, nonverbal, and physical cues, they require less effort to produce than tCMC for convergence processing. Further, the limited symbol sets in tCMC leads to lower social presence, which creates challenges to building the rapport and trust that facilitates the development of shared understandings about situations involving conflict and ambiguity.

Empirical findings provide indirect support for the prediction that using tCMC to engage in convergence processing tasks is difficult for communicators. For example, tCMC communicators take more time to generate the same number of words as face-to-face communicators (Baltes et al., 2002; Tangirala & Alge, 2006; Walther, 1992) and more time to complete a task (Purdy, Nye, & Balakrishnan, 2000). If given restricted amounts of time, tCMC communicators experience fewer changes in understanding (Walther, Anderson, & Park, 1994). Text-based CMC, relative to face-to-face interaction, increases misunderstandings (Cramton, 2001; Swaab et al., 2012) and deception (Jap, Robertson, & Hamilton, 2011; Naquin, Kurtzberg, & Belkin, 2010; Rockmann & Northcraft, 2008), and decreases coordination (Drolet & Morris, 2000; Peñarroja, Orengo, Zornoza, & Hernández, 2013). Getting closer to the consequences of greater communication difficulty in tCMC, several studies have included post-task questions about self-reported effort (Becker-Beck, Wintermantel, & Borg, 2005; Graetz, Boyle,

Kimble, Thompson, & Garloch, 1998; Kock, 2007), generally showing greater perceived effort by tCMC communicators than those communicating face-to-face. While indirect, these findings are consistent with the claim that tCMC makes convergence processing tasks more difficult.

1.2. Communication difficulty, conservation of resources, and motivation maintenance

If a communication task is more difficult, it is likely to require greater effort on the part of communicators. Research on effort expenditures suggest not just links between effort and fatigue, but also monitoring of effort and pre-emptive steps to adjust effort levels to address anticipated fatigue (Hobfoll, 1988; Müller & Apps, 2019). Conservation of resources theory (COR; Hobfoll, 1989) is a theory of motivation that provides a synthesis and set of proposals regarding this body of research.

According to COR, individuals are driven to protect and conserve their current store of resources and to acquire resources to prevent future resource loss (Halbesleben, Neveu, Paustian-Underdahl, & Westman, 2014). Resources in COR are broadly construed as “anything perceived by the individual to help attain his or her goals” (Halbesleben et al., 2014: p. 1338), including time, energy, money, and knowledge. Some resources (e.g., job security) are intrinsically valuable while others (e.g., time, energy) are valuable because they are means to acquiring desirable resources. In the context of day-to-day organizational functioning, employee motivation is a particularly relevant resource because it is central to exerting effort required for addressing job demands. Employees experience motivation for the task at hand when current resources meet or exceed job demands and experience lower motivation when resources appear insufficient for those demands (Quinn et al., 2012). When more resources are used for a current task, it can mean fewer resources will be available for subsequent tasks unless they are replenished. The key relevant prediction from COR theory is that when individuals are faced with the prospect of resource depletion due to exerting greater than expected efforts, they tend to scale back future resource investments to conserve their resources (Hobfoll, Halbesleben, Neveu & Westman, 2018). This is reflected in reduced motivation to exert effort and attention on subsequent tasks—reduced motivation maintenance.

Related research makes similar predictions to this aspect of COR theory. For example, recent theorizing based on neurological evidence about motivational fatigue (Müller & Apps, 2019) proposed that engaging in difficult tasks increases the costs of exerting further effort, thereby reducing the value of exerting effort. A further related claim comes from research on job fatigue and recovery, which proposed that expending effort on difficult tasks “can make people long to have a break, implying a need to stop thinking about the task at hand” (Sonnentag & Zijlstra, 2006, p. 331), suggesting a reduction in motivation maintenance. The proposal then from conservation of resources theory, as well as from related work, is that engaging in difficult tasks is likely to hamper motivation maintenance.

Empirical research from multiple domains is consistent with the idea that sustained effort on difficult tasks reduces motivation maintenance (Hopstaken, van der Linden, Bakker, & Kompier, 2015; van der Linden, Frese, & Sonnentag, 2003). Research following conservation of resources theory has shown, for example, that call center employees soliciting donations tend to exhibit reduced motivation maintenance after effortful communications with customers (Grant et al., 2007). Likewise, prior research has found that communication difficulty associated with effortful social interactions, such as those between individuals of different races, reduces inhibitory control suggesting reduced willingness to persist and exert effort (Richeson & Shelton, 2003; Richeson & Trawalter, 2005). Such studies indicate there could be a general pattern whereby difficult tasks reduce motivation maintenance, and that this pattern could hold for difficult communication tasks.

If the pattern does apply to communication tasks, and if the use of

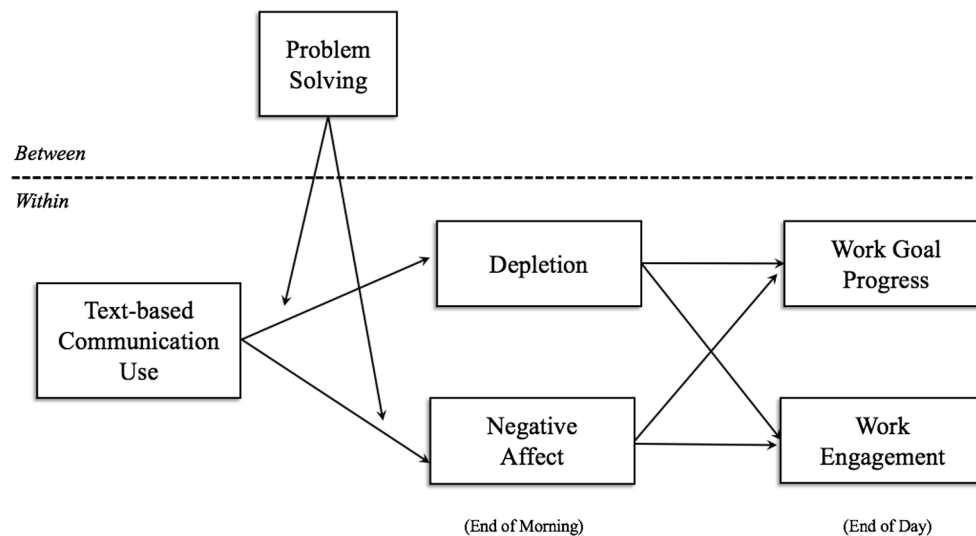


Fig. 1. Study 5 Theoretical Model.

tCMC for convergence processing tasks is indeed difficult, it could influence communicators' motivation maintenance. While convergence processing tasks might be challenging to some extent regardless of communication medium, if the synchronicity and richness of face-to-face communication is better suited to enable communicators to handle these tasks, face-to-face communicators are less likely than tCMC communicators to have reductions in motivation maintenance. Specifically:

Hypothesis 1. *Individuals engaged in work requiring convergence processing using text-based computer-mediated communication, relative to those using face-to-face communication, will be more likely to exhibit reduced motivation maintenance.*

1.3. Motivation maintenance and performance on complex reasoning tasks

The difficulty generated by using tCMC for convergence processing tasks, if it hampers motivation maintenance, expands the scope of communication media effects. Reduced motivation on one's next task could mean tCMC communicators are likely to perform worse, after they have stopped communicating, on complex reasoning tasks. Complex tasks involve the ongoing monitoring and incorporation of multiple dimensions and types of information to solve problems and make decisions (Weber & Johnson, 2009). Complex tasks do not have obvious solutions based on simple, routinized calculations, and so require cognitive effort and willingness to exert sustained effort to arrive at satisfactory solutions.

Organizational members are likely to proceed from one complex task to another. For example, managers might need to negotiate an agreement and then follow up by writing a report. If that negotiation is handled using tCMC, and this reduces a manager's motivational maintenance, it would likely impair the manager's performance on writing the report. More generally, we expect:

Hypothesis 2. *Individuals engaged in work requiring convergence processing using text-based computer-mediated communication, relative to those using face-to-face communication, will perform worse on subsequent individual complex reasoning tasks.*

Hypothesis 3. *The relationship between communication medium use and subsequent individual performance on complex reasoning tasks will be mediated by motivation maintenance.*

The foundational argument that using tCMC for convergence processing reduces motivation maintenance for subsequent tasks is not just

a matter of comparing across communication media. It also applies to variations in levels of tCMC use, as tCMC use varies across days (e.g., Rosen et al., 2019). The earlier theorizing drawing on media synchronicity theory and COR theory would further predict that on days employees use tCMC for convergence processing more often than usual, they are likely to experience more resource depletion than usual. Following COR theory, resource depletion, in turn, is likely to diminish motivation maintenance for subsequent activities. Thus, day to day fluctuations in tCMC use for convergence processing tasks being linked to fluctuations in motivation maintenance provides an opportunity for a further test of the foundational argument.

Separate from variations in daily tCMC use, employee roles vary in the amount of convergence processing they require, with roles rooted in collaborative knowledge work requiring more than roles requiring routine work. Accordingly, we focus on employee jobs requiring problem solving, a key job characteristic of knowledge work that refers to the extent to which a job requires the development of unique solutions or ideas. Employees in high problem-solving jobs are engaged in "generating unique or innovative ideas or solutions, diagnosing and solving nonroutine problems, and preventing or recovering from errors" (Morgeson & Humphrey, 2006: p. 1323). Such activities entail ongoing communication and knowledge sharing with other stakeholders to generate a common understanding about the nature of the problem and to generate possible solutions to resolve the issue (Postrel, 2002). As problem-solving demands of the job increase, employee communications, including tCMC communications, are more likely to be used for convergence processing. In contrast, if problem-solving demands are low for a particular job, then tCMC is less likely to be needed for convergence processing. This means less communication difficulty due to tCMC use and therefore weaker relationships between tCMC use and depletion and, thereby, motivation maintenance.

The theoretical model implied by this reasoning (Fig. 1) captures the expectations that daily tCMC use should be linked to resource depletion mainly for jobs with higher problem-solving demands, as they require communication that likely involves substantial convergence processing. Depletion is predicted to hamper motivation maintenance. According to conservation of resources theory, when employees feel depleted, they are motivated to conserve energy and scale back resource investments. This is likely to adversely affect employee self-regulation (Halbesleben et al., 2014), a cognitive process whose effectiveness depends on energy that employees have available (Lord, Diefendorff, Schmidt, & Hall, 2010). As a result, employees are likely to feel less engaged in work tasks and have a lower sense of accomplishment reflected in their assessments of progress towards daily work goals, both of which indicate employees'

level of motivation maintenance. Work engagement refers to the energy employees have for investment in goal directed tasks at work (Crawford, LePine, & Rich, 2010; Kahn, 1990). Goal progress refers to the extent to which employees feel that they have made headway toward or accomplished their work goals (Koopman, Lanaj, & Scott, 2016; Rosen et al., 2019; Wanberg, Zhu, & Van Hooff, 2010). The key predictions, then, are:

Hypothesis 4a. *Within employees, tCMC use will be positively associated with depletion for those in high problem-solving jobs but have little to no effect on depletion for those in low problem-solving jobs.*

Hypothesis 4b. *Within employees, the indirect effect of tCMC use on (a) work engagement and (b) goal progress via depletion will be negative for employees in high problem-solving jobs. There will be weak or no indirect effect on these two outcomes for those in low problem-solving jobs.*

The theoretical model offered in Fig. 1 also indicates an additional, and potentially alternative, explanation for why greater communication difficulty associated with using tCMC for convergence processing reduces motivation maintenance. It is possible that negative affective reactions due to using tCMC for convergence processing tasks, in addition or in place of feelings of depletion, affect motivation maintenance. Greater communication difficulty can be associated with fatigue, as COR theory would predict, but could also cause negative affective reactions that could be an alternative pathway influencing motivation maintenance. For instance, employees could feel upset, nervous, or stressed out when dealing higher than usual volumes of tCMC (Barley et al., 2011; Rosen et al., 2019), especially when that tCMC involves substantial convergence processing.

1.4. Overview of the studies

The five studies that follow test the proposed relationships between communication medium use on convergence processing tasks, motivation maintenance, and performance on complex reasoning tasks. Data and materials for all the studies are available at: https://osf.io/mjdy9/?view_only=a937b0ec344345f4ad6a8ac179953c85. The first four studies use experimental methods to provide support for the proposed causal relations. Study 1 examines the effect of communication medium use on convergence processing tasks for communicators' motivation maintenance (Hypothesis 1). Study 2 examines the effect on subsequent complex reasoning tasks (Hypothesis 2). Studies 3 and 4 examine whether motivation maintenance mediates the effect of communication medium use on convergence processing tasks for communicators' performance on subsequent complex reasoning tasks (Hypotheses 1, 2, and 3). Study 5 brings these issues back to the field to examine the link between communication medium use on convergence processing tasks and motivation maintenance in more detail and over an extended period (Hypotheses 4a and 4b).

1.5. Sample size and post-hoc design analysis

Sample sizes in Studies 1–4 were based on feasibility and we aimed to achieve a sample size of at least 50 participants in each cell (Simmons, Nelson, & Simonsohn, 2011). Because post-hoc power analyses can overestimate power, we used an alternative approach that assesses the extent to which the observed effect size is likely to be in the incorrect direction (a Type S error i.e., a sign error) or exaggerated in size (a Type M error i.e., a magnitude error) (Gelman & Carlin, 2014). We calculated Type S and Type M errors using Gelman & Carlin's (2014) retrodesign function with estimates of effect sizes and standard errors obtained from each of our studies. We provide these estimates throughout the manuscript. Study 5 used a convenience sample whose size was determined by the number of students enrolled in the classes we surveyed.

2. Study 1

Study 1 examined whether there is a causal effect of communication media use for convergence processing on motivation maintenance. Specifically, dyads either used tCMC or interacted face-to-face to complete an integrative negotiation. Integrative negotiations are common organizational activities (Putnam, 1994) that rely primarily on convergence processes (Dennis et al., 2008). Parties have to reconcile conflicting interests, mixed motives, and the lack of established rules for resolving disagreements to create a shared interpretation of their situation that forms the basis for an integrative agreement (Neale & Northcraft, 1990). Following their negotiations, participants then engaged in an individual task to assess motivation maintenance, the time spent on unsolvable anagrams (Aspinwall & Richter, 1999; Eisenberger & Leonard, 1980; Toburen & Meier, 2010). The key question was whether negotiating using tCMC would lead to lower motivation maintenance.

2.1. Methods

2.1.1. Participants

Participants were 120 upper-level undergraduate students from a large Midwestern university who received course extra credit for their efforts. Participants were 51% female, averaged 20.2 years old, 7% were Hispanic, 51% were white, 42% were Asian, 32% had worked full time (for an average of 9 months), and 83% had worked part time (for an average of 20 months). As we neither predicted nor found effects of these demographic variables in this study or any of the subsequent studies, we do not consider them further. Participants were randomly assigned to negotiate face-to-face or over tCMC.

2.1.2. Materials

We used the "Parkway Drug Case" (Greenhalgh), an integrative negotiation exercise that has long been used to study computer-mediated communication (e.g., Easley, Valacich, & Venkataraman, 2000; George, Easton, Nunamaker, & Northcraft, 1990; Valacich & Schwenk, 1995). Participants were randomly assigned to dyads and given the role of one of the two sales representatives. They negotiated how to re-assign 40 new sales locations and had the option to re-assign 40 additional existing locations. The locations were worth different amounts to the two parties, allowing parties to generate different amounts of value.

2.1.3. Procedure

Participants read their role materials for the Parkway Drug Case. In the face-to-face condition, they then negotiated in person in small rooms. In the tCMC condition, they negotiated using Gmail accounts in a computer lab. Although it was not immediately obvious to participants in the tCMC condition who their partners were, they could and did introduce themselves in the course of their discussions. Participants then worked individually to complete the unsolvable anagram task as an indicator of motivation maintenance. They also completed a post-negotiation questionnaire including measures of demographic variables. Then, they were thanked, debriefed, and dismissed.

2.2. Measures

2.2.1. Motivation maintenance

The number of seconds participants spent on unsolvable anagrams was used as an indicator of motivation maintenance. This is a standard measure in prior research to assess task persistence (e.g., Aspinwall & Richter, 1999; Burkley, 2008; Eisenberger & Leonard, 1980; Moller, Deci, & Ryan, 2006; Toburen & Meier, 2010): the less time participants spent trying to generate solutions to the unsolvable anagrams, the lower their motivation maintenance. Following prior work, the unsolvable anagrams were presented interspersed among a larger number of

Table 1
Study 1. Effect of communication medium on motivation maintenance.

Variable	Time Spent on Unsolvable Anagrams (seconds) ^a 1
Intercept	162.37**
Communication Medium ^b	-43.42*
Pseudo R ²	0.05
Deviance Statistic	1431.4

* $p < .05$.

** $p < .01$.

^a Higher time implies higher Motivation Maintenance.

^b Estimated Change in Dependent Variable when switching from Face-to-face to tCMC.

solvable anagrams. Solving anagrams relies mostly on implicit memory, rather than explicit reasoning (Srinivas & Roediger, 1990). Consequently, while some efforts can be made to consider alternative orderings of the letters, time spent on unsolvable anagrams is largely a function of how long individuals are willing to wait for a solution to come to mind. For this reason, the logic underlying this measure is that the more motivated individuals are, the more they are likely to display persistence and exert mental effort in attempting to jog their memories to yield solutions.

2.2.2. Negotiation performance

Negotiation performance was evaluated based on the total gains produced by the parties with their agreement and was scored on a scale provided by the case authors ranging from 0 (no agreement) to 11 (the optimal gains agreement). Participants described their outcomes, and then were asked to select which of the pre-defined solutions best matched their own, if any. A negotiation expert, not given information about the condition of the participants, confirmed participants' scorings of every solution.

2.2.3. Negotiation time

The number of minutes spent negotiating was assessed by the difference in start and end time stamps from the survey software, averaged across the two members of each dyad. Participants spent up to 32 min to complete their negotiations.

2.3. Results

Consistent with Hypothesis 1, using tCMC to complete an integrative negotiation, relative to communicating face-to-face, led to lower motivation maintenance. Participants who had first negotiated using tCMC later spent less time on unsolvable anagrams ($M = 118.95$ s, $SD = 73.52$) than participants who first negotiated face-to-face ($M = 162.37$ s, $SD = 119.80$). As participants were nested within dyads on the negotiation task, we took a conservative approach and used hierarchical linear modeling (HLM) to control for any intra-dyadic dependencies (Bryk & Raudenbush, 1992) that might have carried over to the individual level assessment of motivation maintenance. Supporting Hypothesis 1, a multilevel model controlling for membership in the dyad indicated that tCMC negotiators displayed significantly less motivation maintenance (Table 1) on the unsolvable anagrams task compared to those negotiating face-to-face ($\gamma = -42.42$, $p = 0.02$, CI: LL = -80.99 UL = -5.85). The tCMC negotiators were predicted to spend 42 fewer seconds on the unsolvable anagrams compared to in-person negotiators, which represents a 26% reduction in motivation maintenance due to tCMC. Because HLM analyses do not provide an overall F test or R^2 , we report Snijders and Bosker's (1999) overall pseudo- R^2 for all multilevel models reported in this paper, which estimates the proportional reduction of Level 1 and Level 2 errors owing to predictors in the model (Table 1). Communication medium explained 5% of the overall variance in motivation

maintenance.

We also conducted analyses that evaluated if the effect size estimate is likely to be in the wrong direction (i.e., a sign or Type S error) or exaggerated in size (i.e., a magnitude or Type M ratio) (Gelman & Carlin 2014). Using the observed effect size, we found the communication medium effect was associated with a Type S error of $<1\%$ and a Type M ratio of 1.27². A Type S error of $<1\%$ indicates that there is a very low probability that communication medium effects are in the wrong direction in terms of their sign. Likewise, the modest Type M exaggeration ratio of 1.27 indicates the possibility that the communication medium effect is overestimated by a factor of 1.27, which is inconsistent with the effect being an unlikely result.

To shed further light on the finding of motivation maintenance on the next task, we assessed several aspects of the initial negotiation task. First, every pair formed an agreement, thus there were no differences in productivity. Second, we did not find a difference in negotiation performance. Pairs in the tCMC condition ($M = 6.50$, $SD = 1.90$) and the face-to-face condition ($M = 6.96$, $SD = 1.92$) performed comparably well, $t(58) = 0.91$, $p = 0.37$. Controlling for negotiation performance, we still found support for the significant effect of communication media on motivation maintenance, ($\gamma = -41.02$, $p = 0.03$, CI: LL = -78.49 UL = -3.54). This provides further support for Hypothesis 1, as time on the unsolvable anagrams was not simply a function of prior task performance.

A third aspect of the negotiation task we examined was the time spent negotiating. As expected based on prior research, face-to-face negotiators tended to complete their negotiations more rapidly ($M = 6.00$ min, $SD = 2.50$) than tCMC negotiators ($M = 20.60$ min, $SD = 5.70$), $t(58) = 16.98$, $p < .001$. Time spent negotiating was virtually indistinguishable from communication medium: the bivariate correlation between time spent negotiating and communication medium was $r = 0.84$. Therefore, we investigated the effects of time spent negotiating on motivation maintenance separately for face-to-face and tCMC communicators. The bivariate correlations between time spent negotiating and motivation maintenance were 0.37 ($p < .01$) for tCMC negotiators and 0.18 ($p = .22$) for face-to-face negotiators. This pattern is consistent with the possibility that time spent engaging in convergence processing to resolve an integrative negotiation hampers motivation maintenance, perhaps particularly so when using tCMC.

2.4. Discussion

This study provided evidence that tCMC led to reduced motivation maintenance on the next task compared to face-to-face communication. There was a causal effect of using tCMC to engage in convergence processing on a second, individual assessment of motivation maintenance. This relationship held even after controlling for negotiation performance, suggesting that the motivation maintenance effect was not a byproduct of a reaction to task performance but instead a product of using the communication medium.

A question raised by this study is whether communication media and time on task are two separate effects contributing to motivation maintenance on the next task. The explanation we offered earlier is that tCMC communication is more difficult and hence tCMC communicators expend greater cognitive effort than face-to-face communicators to reach a shared understanding, which could lead to greater fatigue that reduces motivation to expend effort on the next task. There also may be an effect of greater time on task leading to expending greater cognitive effort that could influence motivation for the next task. The possibility for tCMC to require both more effort per unit of time and also more total time is inherent in studying many real-world tasks, like negotiations, that require individuals to work until the task is done. We also note that

² We used the default degrees of freedom ($df = inf$) in the retrodesign function in this and subsequent calculations of Type S and Type M errors.

allowing participants as much as time as they needed for their negotiations provides important information. It illustrates that real-world use of communication media might have two costs—not only might they require greater effort per unit of time, they might also require more time, further compounding their effects on subsequent motivation. In addition, the greater negotiating time on task by tCMC condition participants, together with their negotiation performance matching that of the face-to-face condition participants, provides important information in that it indicates that the tCMC participants were motivated to complete the negotiation task. If confronting a tCMC negotiation task was simply dispiriting, participants could easily have given up or quickly generated poor agreements (e.g., splitting the locations in half). Yet the greater time on task indicates that tCMC condition participants were engaging seriously with the task. Still, to separate out the issue of total time to complete a task from the effort per unit of time required to engage in convergence processes using tCMC we turn to other tasks that require people to work together for a set period of time.

3. Study 2

Study 2 examined whether there is a causal effect of communication media use for convergence processes on subsequent performance on a complex reasoning task. The initial communication task in Study 2 was a coordination task (Clark & Wilkes-Gibbs, 1986; as used by, for example, Weber & Camerer, 2003). Coordinating on referential relations to establish common ground is nearly entirely about convergence processes (Dennis et al., 2008), and crucial for joint work (Okhuysen & Bechky, 2009). Using a coordination task, as opposed to a negotiation task, allows us to generalize the effects of tCMC to convergence processes and away from any potential variation due to negotiation-specific communication concerns (Adair & Loewenstein, 2013). The complex reasoning task was a common knowledge work task, editing a document. This task, which has been used in prior research (e.g., Grant et al., 2007; Zijlstra, Roe, Leonora, & Krediet, 1999), requires simultaneous attention to multiple dimensions. Specifically, individuals need to consider, simultaneously, syntactic, semantic, and pragmatic concerns at word, sentence, and document-wide levels (Fitzgerald, 1987). Study 2, thus, tests Hypothesis 2, regarding a causal effect of using tCMC for convergence processes on reducing subsequent performance on complex reasoning tasks.

3.1. Methods

3.1.1. Participants

Participants were 102 upper-level undergraduate students from a large Midwestern university participating for course extra credit. They were randomly assigned to communicate face-to-face or using tCMC. Their demographic profile was quite similar to those in Study 1. Participants were 56% male, averaged 22.6 years old, 9% were Hispanic, 56% were white, 35% were Asian, 44% had worked full time (for an average of 3 months), and 85% had worked part time (for an average of 20 months).

3.1.2. Materials and procedure

Participants were randomly assigned to dyads and engaged in a communication task over Gmail or in person. The task was similar to those described in Weber and Camerer (2003) and Clark and Wilkes-Gibbs (1986). We generated 10 sets of highly similar pictures, such that participants would need to describe them in some detail to differentiate them. The sets were of cabinets, cables, chairs, desks, flags, glasses, logos, computer mice, tables, and trashcans. Pictures within each set belonged to a single category and were quite similar but each picture was unique. For each of the 10 sets, communicators had the same pictures but in different orders. In each pair, one person was initially assigned to the guide role. Guides were given a set of 10 pictures, in order, and needed to communicate to their partner, in the arranger role,

so that they could put their set of the same 10 pictures in the same order as the guide's pictures. The partners then changed roles for the next set of pictures; guides became arrangers, and arrangers became guides. To restrict differences across face-to-face and tCMC conditions to communication medium alone, we equalized task difficulty by making sure that partners could not see one another's materials. In the face-to-face condition, the pictures were hidden behind large plastic folders. Thus, guides could not just point out the cards to arrangers but had to communicate verbally with one another to set the cards in the right order. In the tCMC condition, partners were seated out of direct line of sight of one another.

In contrast to Study 1 wherein communicator pairs worked on the negotiation task for as long as needed, pairs in this study were told when to start this task, and then after 20 min were told to stop. That is, across both conditions, pairs worked on the task for exactly the same amount of time. Once pairs had completed the 20 min, they then recorded the pictures they had sorted. Next, participants engaged in an individual complex reasoning task. The task required individuals to read a media story about young entrepreneurs. We introduced 30 errors of different types into the 28-line story. Participants were asked to click on a phrase if the phrase contained an error in need of correcting. Finally, participants completed a post-task questionnaire including questions about their communication process, personality, and demographics.

For this study (and also Studies 3 and 4), we minimized opportunities for social comparisons and cross-participant influence. We prevented pairs from being able to observe how many sets of pictures other pairs completed. Once partners completed their communication task, they worked on their own individual tasks on computers at separate tables. Further, we included questions after the complex reasoning task so that it was unlikely for one participant to complete the entire study before other participants had completed the complex reasoning task. Thus, we minimized the opportunity for participants to have any reason to shape their performance based on observations of others.

3.2. Measures

3.2.1. Complex reasoning task performance

We measured the proportion of the 30 errors participants caught on the editing task as a measure of their complex reasoning task performance. Catching errors in the editing task required deliberately reading and considering syntactic, semantic, and pragmatic aspects for coherence. While simple spelling errors might be caught through non-deliberate recognition of a deviation from overlearned prior experiences, the repeated use of closed class words across a line break or verb tense consistency across embedded clauses are much more likely to require explicit reasoning.

3.2.2. Communication task accuracy

We measured the proportion of accurately placed pictures as a measure of the accuracy with which participants completed the communication task.

3.2.3. Communication task productivity

We measured the number of pictures reported sorted as a measure of pairs' productivity on the communication task.

3.3. Results

Consistent with Hypothesis 2, we found that using tCMC led to lower performance on a complex reasoning task, done after people had stopped communicating. Participants who had communicated using tCMC ($M = 0.43$, $SD = 0.24$) found fewer errors than participants who had communicated in person ($M = 0.53$, $SD = 0.22$). This was supported by multi-level modeling controlling for membership in the dyad for the original communication task, which found a significant difference in between the two conditions ($\gamma = -0.10$, $p = 0.04$, $CI: LL = -0.19$ $UL =$

Table 2
Study 2. Effect of Communication Medium on Complex Reasoning Task Performance.

Variable	Complex Reasoning Task Performance ^a (proportion of errors detected)
Intercept	1
Communication Medium ^b	0.53**
Pseudo R ²	-0.10*
Deviance Statistic	0.04
	-11.10

* $p < .05$.

** $p < .01$.

^a Higher proportion of errors detected higher performance.

^b Estimated Change in Dependent Variable when switching from Face-to-face to tCMC.

-0.01) (Table 2). The estimated difference between tCMC communicators and those who had initially communicated in person in the proportion of errors caught on the later complex reasoning task was 10 percentage points, which is a 19% reduction in complex reasoning task performance for tCMC communicators relative to the average in-person communicator. The overall pseudo- R^2 due to the communication medium effect was 4%. Using the observed effect size, we found the communication medium effect was associated with a Type S error of <1% and a Type M ratio of 1.40.

Prior research comparing tCMC to face-to-face interaction typically finds that face-to-face communicators reliably take less time to complete a given task or, when given the same amount of time, complete more of a given task than do tCMC communicators (e.g., Straus & McGrath, 1994; Tangirala & Alge, 2006; Walther, 2002, 2015). In part, these productivity differences occur because typing takes longer than speaking. Additionally, some features of task performance are made more difficult because of fewer verbal and non-verbal cues in tCMC, making it harder for communicators to resolve task-related ambiguities (Dennis et al., 2008; McGrath & Hollingshead, 1994). This reflects the logic behind our conjectures about higher difficulty with using tCMC compared to face-to-face interaction for tasks involving convergence processing. Supporting this, communication medium was virtually indistinguishable from productivity ($r = 0.86$) in this study: pairs who communicated face-to-face ($M = 74.81$, $SD = 19.13$) sorted more pictures in the 20 min they had to work on the task than those using tCMC ($M = 26.58$, $SD = 10.80$), $t(49) = 16.12$, $p < .001$.

The productivity disparity between tCMC and face-to-face communicators raises the possibility that using tCMC led to lower motivation on the initial task rather than greater information processing difficulties, and this carried over to the complex reasoning task. However, lowered motivation on the initial task would likely result in not just lower productivity but also to lower accuracy. Yet there were no differences in communication task accuracy across conditions, as almost all cards sorted were correctly identified (99%) in both conditions. Thus, we have no evidence that those in the tCMC condition gave up or lowered their quality of work.

We also examined the association between productivity and performance on the complex reasoning task *within* condition. If motivational differences on the initial task lead tCMC communicators to give up to a greater degree than face-to-face communicators, then those who did the least amount of work in tCMC should also have lowest scores on the complex reasoning task due to carryover effects of low motivation. However, the within-condition correlations between number of cards sorted and complex reasoning task performance were non-significant (tCMC: $r = -0.10$, $p = .47$; FTF: $r = 0.07$, $p = .67$), which also suggests that motivational differences are unlikely to be the reason for the productivity disparity between tCMC and face-to-face communicators.

3.4. Discussion

Study 2 examined the effect of having used tCMC for a convergence processing task on later individual performance on a complex reasoning task. Supporting Hypothesis 2, tCMC use led a subsequent drop in a performance, relative to communicating in person for the same length of time, on an unrelated individual task completed after individuals were done communicating. Thus, the costs of communicating using tCMC for convergence processes extend beyond the tasks done while communicating and onwards to later individual activities.

4. Study 3

Study 3 links and extends findings from Studies 1 and 2, and provides a test of Hypothesis 3, the proposal that motivation maintenance will mediate the effects of using tCMC for convergence processing on a complex reasoning task. This study uses the picture sorting coordination task from Study 2 and the measure of motivation maintenance from Study 1. It adds to these a different, pictorial rather than linguistic complex reasoning task to provide further generalization. Thus, Study 3 replicates and extends the first two studies and provides a test of mediation.

4.1. Methods

4.1.1. Participants

Participants were 122 upper-level undergraduate students from a large Midwestern university participating for course extra credit. They were randomly assigned to communicate face-to-face or using tCMC. Participants were 48% male, averaged 20 years old, 4% were Hispanic, 66% were white, 29% were Asian, 48% had worked full time (for an average of 5 months), and 84% had worked part time (for an average of 19 months).

4.1.2. Materials and procedure

Participants were randomly assigned to dyads and began with the same picture-sorting coordination task as in Study 2. This time, the picture sets were presented on computer screens and participants had to type in their responses on their computers. This change meant that both tCMC and face-to-face condition participants were looking at computer screens for the same amount of time. As a result, any difference between the tCMC and face-to-face condition participants' performance cannot be attributed to either differential fatigue from or interest in looking at screens. It also meant that participants had no information on the number of picture sets there were, and so could not generate any expectations about how many picture sets they should be completing. Accordingly, any differences in perceptions about how well or poorly they had done would be due to perceptions of their process rather than information from the experimental materials themselves. Finally, for those working face to face, the laptop screens on which pictures were presented were placed back to back, which prevented members from viewing one another's pictures.

Similar to Study 2, participants in both conditions engaged in the picture sorting communication task for a fixed amount of time. After working on the communication task for 20 min, participants immediately were assessed for motivation maintenance using the unsolvable anagram task from Study 1. Then, participants' performance on a complex reasoning task was assessed using their performance on a set of Raven's progressive matrices. Finally, participants completed a post-task questionnaire asking about the communication process and demographics.

4.2. Measures

4.2.1. Complex reasoning task performance

We used the number of correct responses to six matrices as a measure

Table 3
Study 3. Effect of Communication Medium on Motivation Maintenance and Complex Reasoning Task Performance.

Variables	Time Spent on Unsolvable Anagrams (seconds) ^a	Complex Reasoning Task Performance (number of correct responses)		
	1	1	2	3
Intercept	208.69**	3.84**	2.75**	3.16**
Communication Medium ^b	-46.94*	-0.81*		-0.64 [†]
Time Spent on Unsolvable Anagrams (seconds)			0.01**	0.01*
Pseudo R ²	0.05	0.07	0.07	0.11
Deviance Statistic	1462.1	389.5	386.6	383.3

[†] $p < .10$.

* $p < .05$.

** $p < .01$.

^a Higher time implies higher Motivation Maintenance.

^b Estimated Change in Dependent Variable when switching from Face-to-face to tCMC.

of complex reasoning. Solving Raven's progressive matrices (Raven, 1989) requires drawing inferences about multiple patterns simultaneously. The basic task consists of a three by three matrix of geometric figures, the last of which is left blank. Participants need to select from 8 options the one that completes the pattern. For example, if a series of geometric shapes grew larger from left to right and increased in the number of sides from top to bottom, then a large multi-sided shape might be the correct option. The matrices used in the current study involved the integration of three to four different progressions, none of which were as simple as increasing size or number of sides. Thus, it is a non-verbal task that requires reasoning about and the integration of multiple dimensions of concern. It is often considered a test of fluid intelligence (Raven, 2000), meaning the application of reasoning to solve novel problems not based on prior knowledge, and a test of relational reasoning (Waltz et al., 1999), or the consideration of multiple relations simultaneously. We used advanced rather than more basic matrices from the test to provide a test of complex reasoning.

4.2.2. Motivation maintenance

As in Study 1, we measured motivation maintenance based on time spent by participants on a set of unsolvable anagrams.

4.2.3. Communication task accuracy

As in Study 2, we measured the proportion of accurately placed pictures as a measure of the accuracy with which participants completed the communication task.

4.2.4. Communication task productivity

As in Study 2, we measured the number of pictures reported sorted as a measure of pairs' productivity on the communication task.

4.3. Results

Supporting Hypothesis 1, tCMC condition participants ($M = 161.74$, $SD = 100.01$) showed less motivation maintenance than face-to-face condition participants ($M = 208.69$, $SD = 105.84$), as indicated by their time on unsolvable anagrams. A multilevel analysis controlling for membership in the dyad for the initial communication task found that tCMC negotiators later displayed significantly less motivation maintenance (Table 3) on the unsolvable anagrams compared to those who had communicated face-to-face ($\gamma = -46.95$, $p = 0.04$, CI: LL = -91.46 UL = -2.43). This indicates that tCMC communicators were estimated to spend 47 fewer seconds on the unsolvable anagrams compared to in-person communicators, a 23% reduction in motivation maintenance

due to tCMC use relative to in-person communicators. The overall pseudo- R^2 for the communication medium effect on motivation maintenance was 5%.

Hypothesis 2 also received support. Participants in the tCMC condition ($M = 3.03$, $SD = 1.56$) performed worse on the complex reasoning task than face-to-face condition participants ($M = 3.84$, $SD = 1.42$). This individual level finding was corroborated by a HLM analysis controlling for membership in the dyad used in the earlier communication task, ($\gamma = -0.80$, $p = 0.02$, CI: LL = -1.50 UL = -0.11). This indicated tCMC communicators on average were predicted to score 0.80 points lower than in-person communicators, a 21% reduction in complex reasoning task performance for those who had used tCMC relative to those who had used in-person communication. The overall pseudo- R^2 for the communication medium effect on complex reasoning task performance was 7%. Motivation maintenance also significantly predicted performance on the complex reasoning task in an HLM analysis ($\gamma = 0.004$, $p = 0.01$, CI: LL = 0.001 UL = 0.006), with an overall pseudo- R^2 of 7% attributed to motivation maintenance. Using observed effect sizes, the Type S and Type M errors for the communication medium effect were $<1\%$ and 1.33 respectively for motivation maintenance and $<1\%$ and 1.26 respectively for complex reasoning task performance.

Hypothesis 3 proposed that the relationship between communication medium use and subsequent individual performance on a complex reasoning task would be mediated by motivation maintenance. We used Baron and Kenny's (1986) approach to testing mediation. As reported in tests of Hypothesis 1 and 2, we found support for HLM models wherein communication medium use significantly predicted motivation maintenance ($X \rightarrow M$) and performance on a complex reasoning task ($X \rightarrow Y$) (Table 3). We also found that motivation maintenance was significantly and positively related to performance on a complex reasoning task ($M \rightarrow Y$: Model 2, Table 3). Supporting Hypothesis 3 regarding mediation, a HLM model with communication medium condition and motivation maintenance predicting complex reasoning task performance found that motivation maintenance had a significant effect ($\gamma = 0.003$, $p = 0.01$, CI: LL = 0.0006 UL = 0.001) while the communication medium condition effect turned marginally significant ($\gamma = -0.64$, $p = 0.07$, CI: LL = -1.34 UL = 0.05). The overall pseudo- R^2 for this model was 11% (see Model 3: Table 3). Following MacKinnon, Lockwood, and Williams (2004), we also conducted a test of the significance of the indirect effect using the Monte Carlo method (Selig & Preacher, 2008). The confidence interval around the indirect effect of communication medium on complex reasoning task performance did not include zero ($b = -0.17$; CI: -0.29 , -0.06). Thus, we found support for the mediating effect of motivation maintenance on the relationship between communication medium and complex reasoning task performance.

As expected, there were differences in productivity between conditions: in the 20 min they had to work on the task, pairs who communicated face-to-face ($M = 61.31$, $SD = 18.10$) sorted more pictures than those using tCMC ($M = 15.03$, $SD = 7.11$), $t(59) = 12.89$, $p < .001$. However, there were no reliable differences in the accuracy of their communication task performance, as almost all cards sorted were correctly identified in both conditions, suggesting there was no overall drop in task motivation due to using tCMC but rather an increase in task difficulty. In addition, within condition correlations between productivity (number of cards sorted) and complex reasoning task performance were non-significant (tCMC: $r = -0.10$, $p = .44$; FTF: $r = -0.16$, $p = .18$). Thus, we have no evidence of overall motivational differences between tCMC and face-to-face interaction on the initial task, or of such differences explaining the communication media differences on the later complex reasoning task.

4.4. Discussion

Study 3 replicated and extended findings from Studies 1 and 2. Findings from Study 3 suggest using tCMC for a convergence processing task reduces motivation maintenance compared to interacting in person

and reduces subsequent individual performance on a complex reasoning task. Supporting Hypothesis 3, Study 3 found that motivation maintenance mediated the effect of using tCMC for a convergence processing task on subsequent individual performance on a complex reasoning task.

5. Study 4

Study 4 was a conceptual replication of Study 3. To enhance generalizability, it varied two key elements relative to the prior studies. It used a different initial communication task: a construction task requiring pairs to communicate to assemble tangram puzzles. It also used a different measure of motivation maintenance. In the place of the unsolvable anagrams used in Studies 1 and 3, Study 4 used heuristic responses on the expanded version of the Cognitive Reflection Test (CRT; Frederick, 2005) as an indicator of motivation maintenance.

5.1. Methods

5.1.1. Participants

Participants were 70 upper-level undergraduate students from a large Midwestern university participating for course extra credit. They were randomly assigned to communicate face-to-face or using tCMC. Their demographic profile was quite similar to those in the earlier three studies. Participants were 64% male, averaged 20 years old, 13% were Hispanic, 55% were white, 41% were Asian, and 9% African-American, 39% had worked full time, and 86% had worked part time.

5.1.2. Materials and procedure

Participants were randomly assigned to dyads and worked on a communication task using tCMC or in person. The communication task in this study involved Directors and Assemblers. Directors were shown, on their computer screens, how tangrams (seven standard geometric shapes) could be arranged to make a specific picture (e.g., a candle or sailboat). Assemblers had jumbled plastic pieces of each of the tangram shapes. Directors and Assemblers had to communicate so that the Assemblers could successfully arrange the tangram pieces to form the picture. When done, the Assembler traced the picture so that it could later be scored for accuracy. Then they switched roles, another tangram picture showed on the new Directors' screens, and Assemblers went about trying to arrange another tangram picture. In the face-to-face condition, a barrier separated the two participants so that they could talk but not see each other's computer screens or tangram pieces. In the tCMC condition, the two participants were in separate rooms.

Participants in both conditions worked on the tangram construction task for 20 min. Then, the experimenter stopped participants and they turned to do individual tasks. Participants completed an assessment of motivation maintenance, the Cognitive Reflection Test (Frederick, 2005), and a complex reasoning task, Raven's Matrices. Finally, participants completed a post-task questionnaire asking about the communication process and demographics.

5.2. Measures

5.2.1. Complex reasoning task performance

As in Study 3, we assessed complex reasoning task performance using the number of correct responses to six Raven's matrices.

5.2.2. Motivation maintenance

We used six questions from the expanded version of the Cognitive Reflection Test (Frederick, 2005) as an indicator of motivation maintenance (Toplak, West, & Stanovich, 2013) because it assesses impulsive responding (Baron, Scott, Fincher, & Metz, 2015). The questions in the Cognitive Reflection Test (CRT) consist of logic problems with tempting, seemingly correct answers that require persistence and inhibition to set aside to arrive at the correct answer. Individuals who are unwilling to engage in effortful processing are expected to be more likely to respond

Table 4

Study 4. Effect of Communication Medium on Motivation Maintenance and Complex Reasoning Task Performance.

Variables	Cognitive Reflection Test (number of intuitive but incorrect responses) ^a	Complex Reasoning Task Performance (number of correct responses)		
		1	2	3
Intercept	2.06**	3.89**	4.47**	4.58**
Communication Medium ^b	1.00*	-0.77*		-0.43
Cognitive Reflection Test (number of intuitive but incorrect responses)			-0.38**	-0.34**
Pseudo R ²	0.09	0.06	0.16	0.17
Deviance Statistic	266.2	260.4	252.5	251.1

* $p < .05$.

** $p < .01$.

^a Higher score implies lower Motivation Maintenance.

^b Estimated Change in Dependent Variable when switching from Face-to-face to tCMC.

impulsively and in an automatic fashion by choosing the intuitive but incorrect response. We scored the number of intuitive but incorrect responses as an indicator of (lack of) motivation such that higher scores indicated lower motivation maintenance.

The CRT reflects the sequential two-system theory of judgment, which proposes that many cognitive tasks often involve a fast, intuitive response followed by a slower and more deliberate response that rectifies errors resulting from the intuitive and heuristic processes (Kahneman, 2003). Because the slower, deliberate processing is theorized to be more effortful and rule-based, motivation is required to engage in such deliberate thinking. When individuals are unable to maintain their motivation, they are less likely to persist beyond the quick, heuristic processing to activate slower, deliberate processing.

5.2.3. Communication task accuracy

We measured the ratio of correctly assembled tangram shapes divided by total number of completed shapes as a measure of the accuracy with which participants completed the communication task.

5.2.4. Communication task productivity

We measured the number of tangram pictures formed as a measure of pairs' productivity on the communication task.

5.2.5. Perceived performance

We assessed participant's self-perceived performance on the initial communication task to address whether perceived, rather than actual, task performance helped explain why the initial task might relate to motivation maintenance and complex reasoning task performance. The assessment used three items: How well do you think you did on the Tangram task? How well do you think you did on the Tangram task relative to how other people did? Overall, how satisfied are you with your performance on the Tangram task? Responses were provided on a 7-point Likert type scale. Scale anchors for the first two items ranged from Not at all well (1) to Extremely well (7) and for the third item from Not at all satisfied (1) to Extremely satisfied (7). Coefficient alpha for the three-item measure was 0.93.

5.3. Results

Supporting Hypothesis 1, tCMC condition participants ($M = 3.06$, $SD = 1.79$) chose the intuitive but incorrect response to a greater extent on the CRT than face-to-face condition participants ($M = 2.06$, $SD = 1.49$), thereby showing lower motivation maintenance. There was a significant

effect for communication medium on motivation maintenance using a HLM analysis (Table 4) controlling for membership in the dyad used for the initial communication task ($\gamma = 1.00$, $p = 0.01$, CI: LL = 0.22 UL = 1.79). This suggests participants who initially used tCMC, relative to those initially communicating face to face, showed lower motivation maintenance to overcome their initial, automatic but misleading responses. Our results suggest that tCMC communicators on average were predicted to score 1 point worse than in-person communicators, which is 49% lower performance. The overall pseudo- R^2 for the communication medium effect on motivation maintenance was 9%.

Hypothesis 2 also received support in the data. Participants in the tCMC condition ($M = 3.12$, $SD = 1.64$) later solved fewer matrix problems correctly than face-to-face condition participants ($M = 3.89$, $SD = 1.51$). This finding was corroborated by a HLM analysis controlling for membership in the dyad for the initial communication task ($\gamma = -0.77$, $p = 0.045$, CI: LL = -1.53 UL = -0.17). This indicates that tCMC communicators on average were predicted to score 0.77 points, or 20%, lower than in-person communicators on the subsequent individual level complex reasoning task. The overall pseudo- R^2 for the communication medium effect on complex reasoning task performance was 6%. Using observed effect sizes, the Type S and Type M errors for the communication medium effect were <1% and 1.18 respectively for motivation maintenance and <1% and 1.35 respectively for complex reasoning task performance.

We also found support for Hypothesis 3, which proposed that the relationship between communication medium use and subsequent individual performance would be mediated by motivation maintenance. Tests of Hypothesis 1 and 2 (just shown) provide evidence supporting HLM models wherein communication medium use on a convergence processing task significantly predicted motivation maintenance ($X \rightarrow M$) and performance on a complex reasoning task ($X \rightarrow Y$) (Table 4). We also found that lower motivation maintenance was significantly and negatively related to performance on the complex reasoning task ($M \rightarrow Y$: Model 2, Table 4). Specifically, lower scores on the Cognitive Reflection Test significantly predicted lower subsequent matrix task performance in an HLM analysis, ($\gamma = -0.38$, $p = 0.00$, CI: LL = -0.59 UL = -0.17) with an overall incremental pseudo- R^2 of 16% attributed to motivation maintenance. Supporting mediation as proposed in Hypothesis 3, a HLM model with both communication medium condition and motivation maintenance predicting complex reasoning task performance found that motivation maintenance had a significant effect ($\gamma = -0.34$, $p = 0.00$, CI: LL = -0.56 UL = -0.12) while the communication medium condition effect turned non-significant ($\gamma = -0.43$, $p = 0.24$, CI: LL = -1.17 UL = 0.31). The overall pseudo- R^2 for this model was 17% (Model 3: Table 4). Further, a test of the significance of the indirect effect using the Monte Carlo method (Selig & Preacher, 2008) found that the confidence interval around the indirect effect of communication medium on complex reasoning task performance did not include zero ($b = -0.38$; CI: -0.85, -0.07). Thus, we found support for the mediating effect of motivation maintenance on the relationship between communication medium and complex reasoning task performance (Baron & Kenny, 1986).

Finally, similar to findings about performance on the initial communication task in Studies 2 and 3, pairs who communicated in person showed higher levels of productivity ($M = 3.83$, $SD = 0.19$) than those using tCMC ($M = 1.00$, $SD = 0.20$), $t(33) = 10.14$, $p < .001$. However, the accuracy of pairs' work was similar across conditions (FTF: $M = 0.67$, $SD = 0.10$ and tCMC: $M = 0.71$, $SD = 0.10$; $t(33) = 0.26$, $n.s.$) and within each condition there was no clear relationship between productivity and motivation maintenance (tCMC: $r = 0.00$, $p = .99$; FTF: $r = 0.12$, $p = .50$).

Additionally, communication medium was not clearly associated with perceived performance on the initial communication task ($r = 0.13$, $p = .28$), and a multilevel analysis controlling for dyad membership on the initial communication task found that communication medium condition was not predictive of perceived performance on the

communication task ($t(35) = 1.09$, $p = .28$). Thus, neither actual nor perceived performance on the initial task can explain why tCMC use for convergence processing tasks influence motivation maintenance or subsequent complex reasoning task performance.

5.4. Discussion

Study 4 provided support for the first three hypotheses using a new initial communication task and a new measure of motivation maintenance. A construction task, heavily reliant on convergence processes, when done using tCMC led to lower individual motivation maintenance as indicated by impulsive responses to the Cognitive Reflection Test and, in turn, to lower performance on an individual complex reasoning task in the form of Raven's matrices. Thus, across four studies, three different types of initial communication tasks (a negotiation task, a coordination task, and a construction task), two different ways of measuring motivation maintenance, and two different ways of measuring complex reasoning performance, we found consistent support for communication difficulties due to using tCMC for convergence processes affecting communicators' later individual work.

6. Study 5

Study 5 provided a field-based test of Hypotheses 4a and 4b and the model outlined in Fig. 1: that higher than normal daily tCMC use for those whose jobs requires problem solving (and so convergence processes) is likely to be tied to higher depletion and lower motivation maintenance. Thus, Study 5 examines the hypothesized effects during employees' workdays across multiple tasks, rather than during a single short-term task. The field study drew on full-time employees using an experience sampling methodology (ESM). It provides a key link between the causal tests offered in Studies 1–4 and previous research from field studies showing (negative) associations between tCMC use and employee well-being.

6.1. Method

6.1.1. Participants and procedure

The sample consisted of 123 full-time employed adults enrolled in business programs across two public research universities in the Southeastern United States. Some ($N = 75$) were enrolled in a weekend professional Master's program at one university, while the remaining participants ($N = 48$) were enrolled at another university in an online business degree. Participants received partial course credit for their participation. All students enrolled in classes where the study was offered were invited to participate.

We used an experiential sampling methodology (ESM) to capture the dynamic association between within-person changes in daily text-based communication, depletion, and motivational outcomes. Data were collected over three consecutive work weeks. During the first week, participants completed a background survey, which included an informed consent form and person-level measures of demographics and problem solving. During the second and third weeks, we sent surveys to participants twice daily for 10 consecutive workdays. The first daily survey was sent at the end of the morning and included measures of text-based communication, depletion, negative affect, and face-to-face communication. The second daily survey was sent out at the end of the workday and included measures of goal progress, work engagement, and negative affect.

A total of 159 participants completed our survey. Of these, we only retained in our dataset respondents who fulfilled the following criteria: were working and completed both daily surveys on at least three³ working days. Our final dataset consisted of 123 individuals and 671 day-level observations. Our sample size ($n = 123$) exceeds the recommended level-2 threshold of $n = 83$ for ESM studies (Gabriel et al., 2019). Respondents, on average, completed both daily surveys on 5.48 days ($SD = 1.62$). They had been in their current role for an average of 2.03 years ($SD = 2.41$) and in their organization for an average 3.14 years ($SD = 3.76$) and worked on average for 39.25 h each week ($SD = 11.67$). Participants came from a wide variety of industries such as finance, healthcare, higher education, hospitality, manufacturing, and transportation. Some examples of participant job titles included accounting specialist, HR manager, HR director, customer service manager, and project manager. Participants were 76 percent female, 64.2 percent identified as White⁴.

6.2. Measures

All survey measures were rated using a five-point Likert scale, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*), unless otherwise noted. Participants were instructed to respond to items “since arriving at work today” on the first daily survey. They were instructed to respond to items based on the time that had passed “since taking the last survey” on the second daily survey.

6.2.1. Text-based communication (tCMC) use

Participants reported their daily levels of text-based communication in the end of morning survey using three items created for this study: Since arriving at work today...“I have received more email than is typical”, “I have sent more email than is typical”, “I have had more IM (instant messenger) exchanges than is typical” ($\alpha = 0.74$).

6.2.2. Depletion

We measured daily depletion in the end of morning survey using five items adapted from Twenge, Muraven, and Tice (2004) and used in prior studies (e.g., Johnson, Lanaj, & Barnes, 2014; Mitchell et al., 2019). Example items included: “I have felt drained.”, “I have felt like my willpower is gone.” ($\alpha = 0.93$).

6.2.3. Negative affect

Daily negative affect was measured with the short-form PANAS scale (Watson, Clark, & Tellegen, 1988) in both daily surveys using three items (“nervous”, “upset”, “distressed”). The average alpha coefficient for the three items was 0.84 for the end of morning survey and 0.87 for the end of day survey.

6.2.4. Work goal progress

Participants reported their daily goal progress at the end of each workday using three items from Koopman et al., 2016; adapted from Wanberg et al., 2010: “I have been productive”, “I made good progress on my work goals”, and “I moved forward on my work goals.” ($\alpha = 0.94$).

6.2.5. Work engagement

We measured work engagement at the end of each workday using

³ At the beginning of each daily survey, we asked respondents if that day was a working day and excluded from our dataset surveys completed on non-working days (e.g., vacation days, sick days). As a robustness check, we re-estimated our model without excluding non-working days; results suggest that the conclusions from our main analyses remain unchanged.

⁴ About half of the participants (49.6 percent) were between 25 and 34 years old, 31.7 percent were between 18 and 24 years old, 13.8 percent between 35 and 44 years old; 4.1 percent between 45 and 54 years old, and 0.8 percent were between 55 and 64 years old.

Table 5

Study 5. Percentage of Within-Person Variance among Variables.

Variables	Within-person Variance (e^2)	Between-person Variance (r^2)	% of Within-person Variance
Text-based Communication Use (T1)	0.45	0.29	61%
Depletion (T1)	0.54	0.50	52%
Negative Affect (T1)	0.43	0.49	47%
Work Goal Progress (T2)	0.50	0.13	80%
Work Engagement (T2)	0.49	0.22	69%
Face-to-Face Communication	0.68	0.48	59%
Negative Affect (T2)	0.35	0.58	38%

Note: The percentage of within-person variance was computed as $e^2 / (e^2 + r^2)$.

four items from Rich, Lepine, & Crawford (2010). Example items include “I felt energetic at work today” and “I was excited about my job today.” ($\alpha = 0.88$).

6.2.6. Problem solving

Person-level problem solving was measured in the introductory survey using four items published by Morgeson and Humphrey (2006). Example items include “The job requires unique ideas or solutions to problems.” and “The job involves solving problems that have no obvious or correct answer.” ($\alpha = 0.80$).

6.3. Control variables

6.3.1. Face-to-face communication use

Participants daily levels of face-to-face communication was measured in the end of the morning survey with two items: “I have attended more face-to-face meetings than is typical” and “I have had more face-to-face conversations than is typical.” ($\alpha = 0.88$).

6.4. Analytical strategy

We tested our hypotheses using multilevel path analysis in Mplus 7.31 (Muthén & Muthén, 2015). Given the nested structure of our data, we assessed the suitability of multi-level modelling prior to testing our hypotheses by estimating null models. The results of these analyses (Table 5) indicate the within-person variance of our repeated measures variables ranges from 38% to 80%, signifying that multilevel analyses are appropriate for our data.

We modelled all hypothesized relationships using random slopes and modelled control variable paths using fixed slopes (Enders & Tofighi, 2007). The Level 1 variables (within-person) included daily tCMC use, depletion, negative affect, goal progress, and work engagement. Problem solving was included as a Level 2 (between-person) variable and was grand-mean centered. All within-person predictors were centered around each individual respondent’s mean (Enders & Tofighi, 2007). This helps eliminate between-person confounds (Hofmann, Griffin, & Gavin, 2000) and same-source bias, providing a more accurate assessment of within-person effects (e.g., Foulk et al., 2018).

We included several control variables in our model. Our findings remain qualitatively the same when control variables are excluded from the model (Table A1 in Appendix A). In addition to the controls mentioned above (i.e., face-to-face communication and end-of-day negative affect), we also controlled for artifactual sources of variations (e.g., Tang, Yam, & Koopman, 2020) and included a linear growth term for each day of the study (e.g., 1–10) and a linear term for the day of the week.

6.5. Results

A multilevel confirmatory analysis was performed on the eight

Table 6

Study 5. Descriptive Statistics and Within- and Between-Person Correlations among Study Variables.

Variables	Mean	SD	1	2	3	4	5	6	7	
Level 1 Variables										
1. Text-based Communication (T1)	2.41	0.62	(0.74)	0.33**	0.43**	-0.16	-0.09	0.41**	0.41**	
2. Depletion (T1)	2.49	0.78	0.12**	(0.93)	0.67**	-0.53**	-0.61**	0.13	0.68**	
3. Negative Affect (T1)	2.04	0.75	0.22**	0.45**	(0.84)	-0.37**	-0.40**	0.22*	0.85**	
4. Work Goal Progress (T2)	3.86	0.49	0.01	-0.24**	-0.14**	(0.94)	0.68**	-0.09	-0.50**	
5. Work Engagement (T2)	3.42	0.57	-0.03	-0.38**	-0.14**	0.56**	(0.88)	0.04	-0.50**	
6. Face-to-Face Communication Use (T1)	2.25	0.79	0.27**	0.15**	0.14**	0.03	-0.01	(0.88)	0.22*	
7. Negative Affect (T2)	2.06	0.80	0.09*	0.21**	0.38**	-0.23**	-0.26**	0.02	(0.87)	
Level 2 Variable										
8. Problem Solving	3.56	0.92	0.15	-0.09	0.12	0.12	0.23*	0.25**	0.05	(0.80)

Note. Level-2 $N = 123$; Level-1 $N = 671$. T1 = Time 1 - end of morning; T2 = Time 2 - end of work day. Level 1 variables are person-mean centered; the between person variable is grand-mean centered. Between-person correlations are reported above the diagonal. Within-person correlations are presented below the diagonal ($N = 671$), except for problem solving. Means and standard deviations are calculated using between-person scores. Coefficient alphas are provided along the diagonal.

* $p < .05$
 ** $p < .01$

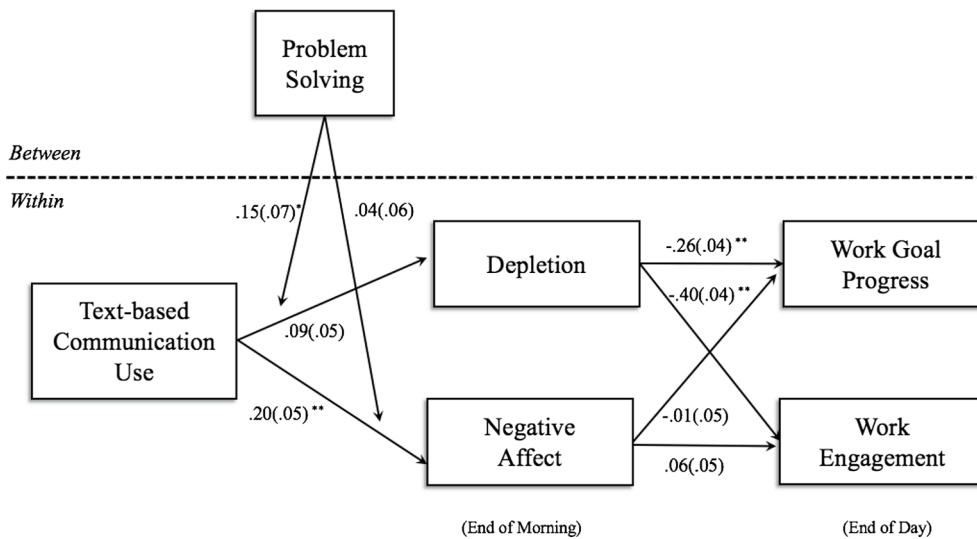


Fig. 2. Study 5. Results of Multilevel Analysis. Note. Level-2 $N = 123$; Level-1 $N = 671$. Estimates are unstandardized. Standard errors are displayed in parentheses. Control variables and direct within-person effects of text-based communication load on goal progress and work engagement were also estimated (see Table 7) but were omitted for clarity.

Table 7

Study 5. Multilevel Path Model Results.

Variables	Depletion (T1)		Negative Affect (T1)		Work Goal Progress (T2)		Work Engagement (T2)		
	γ	SE	γ	SE	γ	SE	γ	SE	
Intercept	2.49**	0.07	2.03**	0.07	4.52**	0.10	4.28**	0.10	
Independent Variables									
Text-based Communication Use	0.09	0.05	0.20**	0.05	0.04	0.05	0.01	0.06	
Problem Solving \times Text-based Communication Use	0.15*	0.07	0.04	0.06					
Mediators									
Depletion					-0.26**	0.04	-0.40**	0.04	
Negative Affect					-0.01	0.05	0.06	0.05	
Controls									
Day of the Study	-0.03*	0.01	-0.01	0.01	-0.02	0.01	-0.01	0.01	
Day of the Week	0.03	0.02	0.01	0.02	-0.01	0.02	0.02	0.02	
Face-to-face Communication	0.11*	0.05	0.07*	0.03	0.07	0.04	0.04	0.04	
End-of-day Negative Affect					-0.22**	0.06	-0.24**	0.05	

Note. Level-2 $N = 123$; Level-1 $N = 671$. Dependent variables were assessed at Time 2 (i.e., end of work day). Time 1 = end of morning survey. Level 1 predictors were person-mean centered.

* $p < .05$
 ** $p < .01$

variables used in the study (two control variables, five variables at the within-person level, and one variable at the between-person level) and the model fit the data well $\chi^2 [211] = 693.87, p = .00$; CFI = 0.93; TLI

= 0.91; RMSEA = 0.06; SRMR_{within} = 0.06; SRMR_{between} = 0.01). The means, standard deviations, and correlations are in Table 6. The findings of the multilevel path analysis are illustrated in Fig. 2; control variables

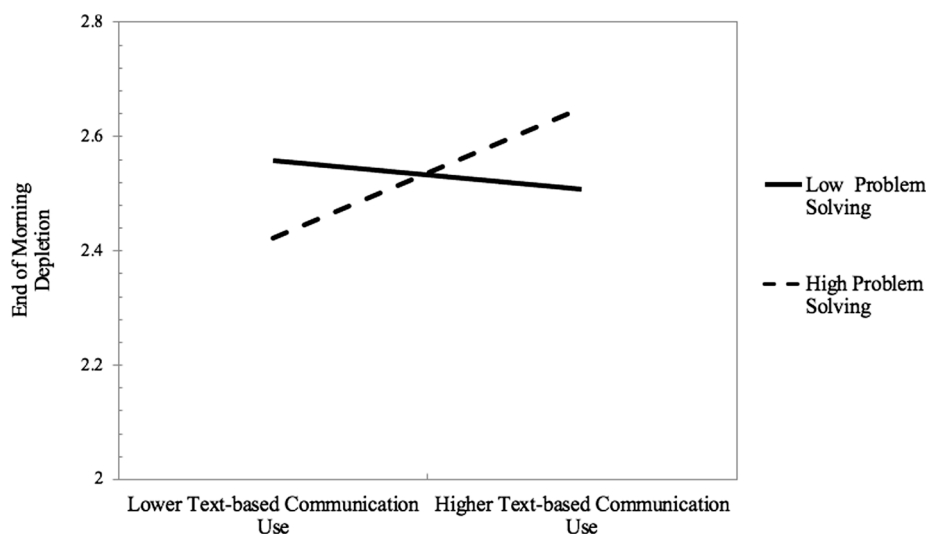


Fig. 3. Study 5. Moderating Effect of Problem Solving on the Relationship between Daily Text-Based Communication and End of Morning Depletion.

and the direct effects of tCMC use on work outcomes were omitted for clarity, however, the full analyses are tabulated in Table 7.

Results show that, within individuals, the main effect of tCMC use on end of morning depletion was positive but not statistically significant ($\gamma = 0.09, p > 0.05$). The main effect of tCMC use on end of morning negative affect was positive and significant ($\gamma = 0.20, p < 0.01$). Depletion had significant main effects on end of day goal progress ($\gamma = -0.26, p < 0.01$) and work engagement ($\gamma = -0.40, p < 0.01$) but end of morning negative affect did not significantly influence either variable.

Supporting hypothesis 4a, problem solving significantly moderated the relationship between tCMC use and depletion ($\gamma = 0.15, p < 0.05$). Fig. 3 illustrates the plot of this interaction. Following recommendations by Preacher, Curran, & Bauer (2006), we computed simple slopes at high (+1 SD) and low (-1 SD) levels of problem solving. Consistent with hypothesis 4a, we find that the relationship between tCMC use and depletion is positive and significant for individuals who work in jobs with high problem-solving demands (slope = 0.23, SE = 0.08, $p < 0.05$) but is not significant for those in jobs with low problem-solving demands (slope = -0.05, SE = 0.08, $p > 0.05$).

Hypothesis 4b predicted that daily tCMC use would have negative and significant indirect effects on goal progress and work engagement via depletion when problem solving is high but not when it is low. We estimated confidence intervals for these indirect effects at high (+1 SD) and low (-1 SD) levels of problem solving. As predicted, the indirect effect of text-based communication on goal progress (-0.06, 95% CI: [-0.10, -0.01]) and on work engagement (-0.09, 95% CI: [-0.15, -0.03]) via depletion was negative and significant when problem solving is high. It was not significant when problem solving is low (0.01, 95% CI: [-0.03, 0.05]) for goal progress and for work engagement (0.02, 95% CI: [-0.04, 0.08]). With regards to the alternate explanation linking tCMC use to reduced motivation via negative affect, although tCMC use had a significant and positive effect on end of morning negative affect, the moderating effect of problem solving on the tCMC use-negative affect relationship was not significant ($\gamma = 0.04, p > 0.05$). The direct effects of end of morning negative affect on goal progress and work engagement were not significant. Relatedly, conditional indirect effects of tCMC use on goal progress and work engagement mediated by negative affect were not significant when problem solving was high or low.

6.6. Study 5 discussion

Study 5 provided additional evidence in support of our theorizing that tCMC use for convergence processing can have downstream

negative consequences for motivation maintenance. This is demonstrated by tCMC's negative and significant indirect effects through depletion on goal progress and work engagement for employees in jobs with high problem-solving demands. It had no effect on these outcomes for jobs with low problem-solving demands. This study strengthens conclusions about our theorizing drawn from our experimental lab studies by showing they extend to employees in organizational settings. Additionally, Study 5 also directly tested a key psychological mechanism—depletion—that was implied by our theorizing but not explicitly tested in Studies 1–4. Thus, it provides a more direct test of our theorizing that the greater communication effort involved in using tCMC for convergence processing tasks leads to depletion and hence reduced downstream motivation on subsequent tasks. It also helped to rule out negative affect as an alternative explanation for the links between using tCMC for convergence processing tasks and diminished motivation.

7. General discussion

The benefits of tCMC for collaborative work come with greater costs to communicators than we knew. A crucial assumption underlying theorizing about communication media is that working over tCMC to create shared understandings of complex and ambiguous work situations is more difficult than working together in person (Daft & Lengel, 1986; Dennis et al., 2008; Swaab et al., 2012). The advance here is to provide causal evidence and field evidence that those difficulties are not limited to the communication task itself, but extend to the people doing the communicating.

Drawing on media synchronicity theory and conservation of resources (COR) theory, we hypothesized hidden costs of tCMC use for convergence processing tasks on communicators in the form of reduced motivation maintenance and then lower performance on later complex reasoning tasks. Together, results from four experimental studies examining several tasks relying on convergence processing showed that using tCMC, relative to communicating in person, compromised motivation maintenance (Studies 1, 3, & 4) and reduced downstream performance on subsequent complex reasoning tasks (Studies 2, 3, & 4). Further, findings (Studies 3 and 4) suggest that motivation maintenance mediates the effect of communication media differences on subsequent complex reasoning task performance.

A fifth study, a field study employing an ESM design, complemented the findings from the experiments and further clarified the mechanisms through which tCMC use for convergence processing could hamper motivation maintenance. Findings from Study 5 suggest that on days with higher tCMC use relative to days with lower tCMC use, employees

are more likely to be depleted if they are in high problem-solving jobs. Day-to-day variation in tCMC use did not have any effect on depletion for employees in low problem-solving jobs. This pattern of results provides support for the earlier theorizing that tCMC use for convergence processing tasks is particularly challenging, and leads to higher depletion. Further, for high problem solving jobs, tCMC had an indirect negative effect via depletion on two indicators of motivation maintenance: employee engagement and work goal progress. The Study 5 findings did not find support for negative affect as an explanation for why tCMC use for convergence processing has downstream effects on motivation maintenance.

Altogether, the findings across these five studies were consistent with the current theorizing based on integrating media synchronicity theory with COR theory: the greater communication difficulty associated with tCMC use for convergence processing tasks has consequences for individual communicators even after they are no longer communicating. The greater depletion and decreased motivation maintenance are burdens communicators carry with them that lower their performance on complex reasoning tasks.

7.1. Extending media synchronicity and COR theories

In focusing on the downstream consequences of communication media use, the studies in this paper build on and extend a central, yet empirically under-examined, claim made by multiple communication media theories. The claim is that communication media differ in how cognitively difficult they make it to work on communication tasks requiring convergence processing. This claim is central to the arguments of media synchronicity theory (Dennis et al., 2008), as well as related work on media richness theory (Daft & Lengel, 1986) and media naturalness theory (Kock, 2004). The current studies provided strong tests of this claim and find support for it by showing communication media differences in subsequent motivation and complex reasoning. Thus, the current studies provide a new kind of empirical support for central theoretical arguments about communication media use.

The current studies also extend the scope of these lines of theorizing. In particular, according to media synchronicity theory, the costs of task-medium misfit are reflected primarily as performance inefficiencies for the task done while communicating. But if the effects extend to communicators and subsequent task performance, then media synchronicity theory's implications are notably broader. They include immediate effects on specific follow-on tasks, as found in Studies 1–4. They also include cumulative effects on individuals over the course of working days as found in Study 5. Over time, these immediate and accumulating effects on employee motivation could in the aggregate contribute to lowered productivity as well as burn-out and stress. Given how much of organizational life, particularly managerial life, hinges on communicating, communication difficulty costs are already valuable contributors to the design of work arrangements (Daft & Lengel, 1986; Dennis et al., 2008). Updating prior theorizing and discussion to incorporate costs to communicators in the distribution of organizational work and the aggregate pattern of work arrangements is an opportunity.

The current paper also extends theorizing on conservation of resources theory by identifying communication medium choice as a hidden, and hence overlooked, source of resource loss in organizations. The current studies indicate that employees' choices of communication media could potentially be consequential for performance on subsequent tasks through a process of resource conservation (Hobfoll, 1998). This signals a more strategic role for organizational communication norms in managing employee energy. While prior COR research has identified several resources including personality (e.g., conscientiousness), job characteristics (e.g., autonomy) and organizational policies (e.g., work-family policies) (Halbesleben et al., 2014), there has yet to be a focus on organizational communication. The current research adds to the portfolio of organizationally relevant resources included under COR. It also serves as a potential moderating factor for existing COR theory

and data. Specifically, engaging with other people with whom one has a positive relationship generally acts as a supportive resource (Halbesleben, 2006). It is possible that the effects of these social engagements could vary by communication medium and task type. More generally, understanding how communication contributes to resource gains and losses is an opportunity.

7.2. Implications

Given the growing importance of virtual work in organizational life and employees' dependence on tCMC to complete a wide variety of organizational tasks (Gibson et al., 2014), the current findings raise new concerns about the hidden costs of text-based virtual collaboration for tasks requiring convergence processing such as negotiation and coordination. Importantly, the hidden costs of tCMC identified in these studies are not arguments against either virtual work arrangements or the use of tCMC. Instead, identifying new costs to communicators of using tCMC for tasks requiring convergence processing helps improve decisions about what communication media to use when. Text-based communication media such as email offer some widely understood benefits to organizational members, including convenience, cost savings, and closure (Straub & Karahanna, 1998). Scheduling demands and spatial or temporal dispersion can make working in person impractical (e.g., Gajendran & Joshi, 2012; Gibson & Gibbs, 2006). Yet how impractical is based on an estimate of the costs. The current findings, by indicating a new kind of cost, provide additional guidance to individuals, groups, and organizations so they can make better decisions about communication media use and virtual work arrangements.

Such guidance is especially critical given the expectation that many disruptions, including but not limited to global pandemics, increase the widespread use of remote work (Ford, 2021). The COVID-19 pandemic spurred adoption of higher synchronicity communication media such as Zoom as substitutes for in-person interaction when working remotely. In addition, remote work also increases reliance on lower synchronicity text-based communication media for getting work done (Gajendran & Harrison, 2007), as coordinating synchronous interactions is not simple for remote workers. Personalized schedules due to schedule flexibility afforded by remote work makes planning synchronous interactions challenging. Likewise, companies are offering greater geographic flexibility to remote workers (Choudhury, 2020; Choudhury, Foroughi, & Larson, 2021). This increases the difficulty of coordinating synchronous interaction as more employees work across multiple time zones. All this likely means organizations increase their reliance on tCMC for all types of tasks, including those involving convergence processing.

Greater use makes it all the more important to study and make salient the costs of tCMC use for motivation maintenance and subsequent complex reasoning. These costs may not be obvious. The differences between face-to-face interaction and tCMC on task performance while communicating are fairly large and so fairly apparent. The effect of having used tCMC for convergence processing was smaller but hardly trivial. As a result, the current findings provide evidence that gives researchers and managers reasons to incorporate a heretofore hidden factor that could influence the decision-making calculus about whether it is more efficient to work together over tCMC or make efforts to be in person. The implications of the current study are that tasks requiring substantial convergence processes, where working through ambiguities and different perspectives to arrive at a collective understanding are key, are probably worth working harder to avoid doing using tCMC.

7.3. Limitations and future research directions

The focus of the current studies was on downstream effects of communication media on motivation and performance on complex reasoning tasks. Future research could attempt to provide a richer picture of the effects of tCMC on individuals. For instance, future research could examine whether communication difficulty and its accumulated

effects on motivation maintenance contribute to increased stress levels as a means of linking this research with work on burn-out and tCMC use (Barley et al., 2011). Or it could be used to examine effects on lower levels of individuals' moral awareness and increased risks for tasks with ethical consequences (Gino, Schweitzer, Mead, & Ariely, 2011). There are surely other potential effects to examine.

The current studies focused on text-based CMC, because of its central role in organizational communication. Despite the plethora of organizational communication options, it has remained the most widespread and successful form of organizational communication for over two decades (Dabbish & Kraut, 2006). Yet, a useful extension of these studies could be to study other communication media. For instance, emerging theory (Bailenson, 2021) and evidence (Fauville et al., 2021) on the phenomenon of Zoom fatigue during the pandemic suggests that other communication media could also contribute to the motivational costs associated with virtual work.

One limitation of our studies is that tests of our theory relied on commonly used tCMC tools (e.g., email and IM). There has also been a rise in use of communication tools, such as Microsoft Teams, Slack, Google Docs, and so forth, that include tCMC as a modality that users could configure in ways that ease communication difficulty associated with convergence processing tasks by allowing a blending of communication types. For example, employees using such tools might encounter difficulties with a complex issue and switch from tCMC to a video call or an in-person conversation. Alternatively, communicators may blend multiple tCMC tools to reduce ambiguity and communication difficulty (e.g., use Google Docs to jointly edit a document while also engaging in email or IM communication).

Given the pervasiveness of text-based virtual communication for remote and in-office workers, the hidden motivational costs of tCMC may be less noticeable compared to those from new communication media. Future research could examine the total costs of communication media use on individuals, beyond the communication tasks themselves. The motivational maintenance effects could extend beyond work to affect energy and performance in the personal domain, including personal health. The current studies emphasized modern knowledge work, which places a particularly strong emphasis on individuals spending their time working on computers. It could be valuable to examine effects on other sorts of individual work, as well as group work.

The focus of the first four studies was on the effects of a communication task on later individual work, and it is an open question how the effects would extend to a second communication task. A second communication task might minimize task switching costs and so reduce the observed decrements to motivational maintenance and subsequent task performance. It is also possible that any second task would see a decrement, simply because of the work involved in the initial communication task, in line with the current theorizing.

A potential limitation of Study 5 is its reliance on self-report data, which raises common method variance (CMV) concerns. Still, predictor and outcome measures were assessed at different times, which reduces concerns that momentary factors such as mood could have influenced participant responses (Podsakoff, MacKenzie, & Podsakoff, 2012). Further, because within-person variables were person-mean centered, it alleviates concerns that between-person confounds (e.g., social desirability) could be driving our results (Raudenbush & Bryk, 2002). Finally, CMV is unlikely to explain the moderation effects due to the extent of complex problem solving involved in one's job found in Study 5, as interaction effects are unlikely to occur spuriously as a result of common method variance (Siemsen, Roth, & Oliveira, 2010). Altogether then, while CMV is unlikely as an alternate explanation for the current findings, additional research would be welcome.

Another limitation of Study 5 is that it assumes that tCMC was used for convergence processing. The study did not directly assess whether this was so. Instead, we inferred this was the case by using the centrality of problem solving to one's job as an indicator of the likelihood of convergence processing. Indeed, it would be difficult to accurately

assess tCMC use for convergence processing in real world contexts without intrusive monitoring of communication activity, which may give rise to other methodological problems. Still, it might be feasible to identify specific tasks and the communication media used for them as a means of getting a still more proximal assessment. Another limitation of the current studies is that it is not clear how to identify or create tasks that differ only in the degree of convergence processing called for. While it might be ideal to compare effects of engaging in a task that differs only in the degree of convergence processing, doing so is practically difficult⁵.

Among the more promising possibilities for future research might be to attempt to extend Study 5 by examining email archives in combination with survey methods to gain a more complete understanding of the costs of tCMC use for motivation maintenance. Content analyses of communication efforts might also be beneficial for insight into convergence processing amounts as well as communication costs and motivation maintenance.

Despite an emerging trend to examine the antecedents and consequences of employee energy in the workplace (e.g., Schwartz & McCarthy, 2007), the possibility that widespread use of tCMC in organizations can have implications for employee energy and performance has not been explored in any of the streams of research in Quinn et al. (2012) extensive review of research addressing human energy at work. Incorporating communication media choice as an influence on the energy communicators have available for subsequent individual tasks could be a fruitful avenue for future research.

Finally, future research could identify ways to neutralize the communication difficulty costs of email or to re-energize individuals after using email. For example, research on recovery following work strain suggests that micro-breaks (e.g., informal social interactions, stretching, coffee breaks) could potentially help tCMC communicators working on convergence processing recoup drops in motivational resources (e.g., Kim, Park, & Niu 2017). Similarly, restorative environments such as a walk in natural settings or even just providing views of natural settings such as parks and gardens could contribute to motivation maintenance (Kaplan, 1995). Even viewing nature pictures and videos on a computer screen can be a restorative experience (e.g., Berman, Jonides, & Kaplan, 2008; Beute & de Kort, 2014). Examining which interventions are effective have more than practical value. They could also be informative about the contributors to the costs of tCMC use.

7.4. Conclusion

The current findings indicate downstream effects of the communication difficulty associated with tCMC use for convergence processes on the people doing the communicating. Generating awareness of these downstream effects could help employees better manage the trade-offs inherent to their communication media choices. Generating new theory based on shifting attention from communication task effects to effects on communicators is an opportunity for scholars to connect the

⁵ We note here that in further studies, we contrasted tCMC and in person communication in two studies with less complex communication tasks involving a greater proportion of conveyance processing: a study involving single-issue distributive negotiations instead of the multi-issue integrative negotiation in Study 1 and a study involving contrasts between tCMC and in person communication to sort unambiguous images instead of the ambiguous images used in Study 2. In both studies, there were no communication media differences on individual motivation maintenance using similar sample sizes and measures to those in Studies 1 and 2. We note these null effects with caution, mostly to emphasize the difficulty in assessing and manipulating the amount of convergence processing people undertake. It is also part of the reason why the current use of problem solving as an index of convergence processing appeared to be a reasonable alternative. Details of these two studies are available on request.

Table A1
Study 5. Results of Multilevel Path Analyses for Study 5 without Control Variables.

Variables	Depletion (T1)		Negative Affect (T1)		Work Goal Progress (T2)		Work Engagement (T2)	
	γ	SE	γ	SE	γ	SE	γ	SE
Intercept	2.49**	0.07	2.03**	0.07	4.57**	0.10	4.36**	0.10
<i>Independent Variables</i>								
Text-based Communication Use	0.13*	0.05	0.23**	0.05	0.06	0.06	0.01	0.06
Problem Solving \times Text-based Communication	0.15*	0.07	0.04	0.06				
<i>Mediators</i>								
Depletion					-0.25**	0.04	-0.40**	0.04
Negative Affect					-0.05	0.05	0.02	0.05

Note. Level-2 $N = 123$; Level-1 $N = 671$. Dependent variables were assessed at Time 2 (i.e., end of work day). Time 1 = end of morning survey.

* $p < .05$.

** $p < .01$.

pervasive use of communication media in contemporary organizational life to an array of important outcomes.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

See Table A1.

References

- Abramovich, G. (2019). If you think email is dead, think again. Retrieved May 1, 2021. <https://blog.adobe.com/en/publish/2019/09/08/if-you-think-email-is-dead-think-again.html#gs.lvy4at>.
- Adair, W. L., & Loewenstein, J. (2013). Talking in through: Communication sequences in negotiation. In M. Olekalns, & W. L. Adair (Eds.), *Handbook of research in negotiation* (pp. 311–331). London, UK: Edgar.
- Alavi, M., & Leidner, D. E. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly*, 25(1), 107–136.
- Alge, B. J., Wiethoff, C., & Klein, H. J. (2003). When does the medium matter? Knowledge-building experiences and opportunities in decision-making teams. *Organizational Behavior and Human Decision Processes*, 91(1), 26–37.
- Aspinwall, L. G., & Richter, L. (1999). Optimism and self-mastery predict more rapid disengagement from unsolvable tasks in the presence of alternatives. *Motivation and Emotion*, 23(3), 221–245.
- Bailenson, J. N. (2021). Nonverbal overload: A theoretical argument for the causes of Zoom fatigue. *Technology, Mind, and Behavior*, 2(1).
- Baltes, B. B., Dickson, M. W., Sherman, M. P., Bauer, C. C., & LaGanke, J. S. (2002). Computer-mediated communication and group decision making: A meta-analysis. *Organizational Behavior and Human Decision Processes*, 87(1), 156–179.
- Barley, S. R., Meyerson, D. E., & Grodal, S. (2011). E-mail as a source and symbol of stress. *Organization Science*, 22(4), 887–906.
- Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, 51(6), 1173–1182.
- Baron, J., Scott, S., Fincher, K., & Metz, S. E. (2015). Why does the Cognitive Reflection Test (sometimes) predict utilitarian moral judgment (and other things)? *Journal of Applied Research in Memory and Cognition*, 4(3), 265–284.
- Becker-Beck, U., Wintermantel, M., & Borg, A. (2005). Principles of regulating interaction in teams practicing face-to-face communication versus teams practicing computer-mediated communication. *Small Group Research*, 36(4), 499–536.
- Berman, M. G., Jonides, J., & Kaplan, S. (2008). The cognitive benefits of interacting with nature. *Psychological Science*, 19(12), 1207–1212.
- Beute, F., & de Kort, Y. A. W. (2014). Natural resistance: Exposure to nature and self-regulation, mood, and physiology after ego-depletion. *Journal of Environmental Psychology*, 40, 167–178.
- Bordia, P. (1997). Face-to-face versus computer-mediated communication: A synthesis of the experimental literature. *Journal of Business Communication*, 34(1), 99–118.
- Burkley, E. (2008). The role of self-control in resistance to persuasion. *Personality and Social Psychology Bulletin*, 34(3), 419–431.
- Bryk, A. S., & Raudenbush, S. W. (1992). *Hierarchical linear models: Applications and data analysis methods*. Newbury Park, CA: Sage.
- Canessa, E., & Riolo, R. L. (2006). An agent-based model of the impact of computer-mediated communication on organizational culture and performance: An example of the application of complex systems analysis tools to the study of CIS. *Journal of Information Technology*, 21(4), 272–283.
- Choudhury, P. (2020). Our work-from-anywhere future. Retrieved, May 1, 2021, from <https://hbr.org/2020/11/our-work-from-anywhere-future>.
- Choudhury, P., Foroughi, C., & Larson, B. (2021). Work-from-anywhere: The productivity effects of geographic flexibility. *Strategic Management Journal*, 42(4), 655–683.
- Chui, M., Manyika, J., Bughin, J., Dobbs, R., Roxburgh, C., Sarrazin, H., Sands, G., & Westergren, M. (2012, July). The social economy: Unlocking value and productivity through social technologies, McKinsey Global Institute. Retrieved May 1, 2021, from <https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/the-social-economy>.
- Clark, H. (1996). *Using language*. New York: Cambridge University Press.
- Clark, H. H., & Wilkes-Gibbs, D. (1986). Referring as a collaborative process. *Cognition*, 22(1), 1–39.
- Cramton, C. D. (2001). The mutual knowledge problem and its consequences for dispersed collaboration. *Organization Science*, 12(3), 346–371.
- Crawford, E. R., LePine, J. A., & Rich, B. L. (2010). Linking job demands and resources to employee engagement and burnout: A theoretical extension and meta-analytic test. *Journal of Applied Psychology*, 95(5), 834–848.
- Cropley, A. (2006). In praise of convergent thinking. *Creativity Research Journal*, 18(3), 391–404.
- Dabbish, L. A., & Kraut, R. E. (2006). Email overload at work: An analysis of factors associated with email strain. In *Proceedings of the 2006 20th anniversary conference on computer supported cooperative work*, ACM, pp. 431–440.
- Daft, R. L., & Lengel, R. H. (1984). Information richness: A new approach to manager information processing and organizational design. In B. M. Staw, & L. L. Cummings (Eds.), *Research in organizational behavior* (pp. 191–233). Homewood, IL: JAI Press.
- Daft, R. L., & Lengel, R. H. (1986). Organizational information requirements, media richness and structural design. *Management Science*, 32(5), 554–571.
- Dennis, A. R., Fuller, R. M., & Valacich, J. S. (2008). Media, tasks, and communication processes: A theory of media synchronicity. *MIS Quarterly*, 32(3), 575–600.
- Dennis, A. R., & Valacich, J. S. (1999). Rethinking media richness: Towards a theory of media synchronicity. In *Proceedings of the 32nd Hawaii international conference on system sciences*, IEEE, pp. 1–10.
- Drolet, A. L., & Morris, M. W. (2000). Rapport in conflict resolution: Accounting for how face-to-face contact fosters mutual cooperation in mixed-motive conflicts. *Journal of Experimental Social Psychology*, 36(1), 26–50.
- Enders, C. K., & Tofighi, D. (2007). Centering predictor variables in cross-sectional multilevel models: A new look at an old issue. *Psychological Methods*, 12(2), 121–138.
- Easley, R. F., Valacich, J. S., & Venkataraman, M. A. (2000). Capturing group preferences in a multicriteria decision. *European Journal of Operational Research*, 125(1), 73–83.
- Eisenberger, R., & Leonard, J. M. (1980). Effects of conceptual task difficulty on generalized persistence. *The American Journal of Psychology*, 285–298.
- Fauville, G., Luo, M., Muller Queiroz, A. C., Bailenson, J. N., & Hancock, J. (2021). Nonverbal mechanisms predict Zoom fatigue and explain why women experience higher levels than men. Available at SSRN 3820035.
- Fayard, A. L., & Metiu, A. (2014). The role of writing in distributed collaboration. *Organization Science*, 25(5), 1391–1413.
- Fitzgerald, J. (1987). Research on revision in writing. *Review of Educational Research*, 57(4), 481–506.
- Ford, B. (2021). Many businesses see hybrid work continuing after pandemic. Retrieved May 1, 2021, from <https://www.bloomberg.com/news/articles/2021-03-25/man-y-businesses-see-hybrid-work-continuing-after-pandemic>.
- Foulk, T. A., Lanaj, K., Tu, M. H., Erez, A., & Archaibeau, L. (2018). Heavy is the head that wears the crown: An actor-centric approach to daily psychological power, abusive leader behavior, and perceived incivility. *Academy of Management Journal*, 61(2), 661–684.
- Frederick, S. (2005). Cognitive reflection and decision making. *The Journal of Economic Perspectives*, 19(4), 25–42.
- Gabriel, A. S., Podsakoff, N. P., Beal, D. J., Scott, B. A., Sonnentag, S., Trougakos, J. P., & Butts, M. M. (2019). Experience sampling methods: A discussion of critical trends and considerations for scholarly advancement. *Organizational Research Methods*, 22(4), 969–1006.
- Gajendran, R. S., & Harrison, D. A. (2007). The good, the bad, and the unknown about telecommuting: Meta-analysis of psychological mediators and individual consequences. *Journal of Applied Psychology*, 92, 1524–1541.

- Gajendran, R. S., & Joshi, A. (2012). Innovation in globally distributed teams: The role of LMX, communication frequency, and member influence on team decisions. *Journal of Applied Psychology*, 97(6), 1252–1261.
- Gelman, A., & Carlin, J. (2014). Beyond power calculations: Assessing type S (sign) and type M (magnitude) errors. *Perspectives on Psychological Science*, 9(6), 641–651.
- George, J. F., Easton, G. K., Nunamaker, J. F., Jr, & Northcraft, G. B. (1990). A study of collaborative group work with and without computer-based support. *Information Systems Research*, 1(4), 394–415.
- Gibson, C. B., & Gibbs, J. L. (2006). Unpacking the concept of virtuality: The effects of geographic dispersion, electronic dependence, dynamic structure, and national diversity on team innovation. *Administrative Science Quarterly*, 51(3), 451–495.
- Gibson, C. B., Gibbs, J. L., Stanko, T. L., Tesluk, P., & Cohen, S. G. (2011). Including the “I” in virtuality and modern job design: Extending the job characteristics model to include the moderating effect of individual experiences of electronic dependence and copresence. *Organization Science*, 22(6), 1481–1499.
- Gibson, C. B., Huang, L., Kirkman, B. L., & Shapiro, D. L. (2014). Where global and virtual meet: The value of examining the intersection of these elements in twenty-first-century teams. *Annual Review of Organizational Psychology and Organizational Behavior*, 1(1), 217–244.
- Gino, F., Schweitzer, M. E., Mead, N. L., & Ariely, D. (2011). Unable to resist temptation: How self-control depletion promotes unethical behavior. *Organizational Behavior and Human Decision Processes*, 115(2), 191–203.
- Graetz, K. A., Boyle, E. S., Kimble, C. E., Thompson, P., & Garloch, J. L. (1998). Information sharing in face-to-face, teleconferencing, and electronic chat groups. *Small Group Research*, 29(6), 714–743.
- Grant, A. M., Campbell, E. M., Chen, G., Cottone, K., Lapedis, D., & Lee, K. (2007). Impact and the art of motivation maintenance: The effects of contact with beneficiaries on persistence behavior. *Organizational Behavior and Human Decision Processes*, 103(1), 53–67.
- Greenhalgh, L. (no date). Parkway Drug Company. Amos Tuck School of Management, Dartmouth University.
- Halbesleben, J. R. (2006). Sources of social support and burnout: A meta-analytic test of the conservation of resources model. *Journal of Applied Psychology*, 91(5), 1134–1145.
- Halbesleben, J. R., Neveu, J. P., Paustian-Underdahl, S. C., & Westman, M. (2014). Getting to the “COR” understanding the role of resources in conservation of resources theory. *Journal of Management*, 40(5), 1334–1364.
- Hobfoll, S. E. (1988). *The ecology of stress*. New York: Hemisphere.
- Hobfoll, S. E. (1989). Conservation of resources: A new attempt at conceptualizing stress. *American Psychologist*, 44(3), 513.
- Hobfoll, S. E., Halbesleben, J., Neveu, J. P., & Westman, M. (2018). Conservation of resources in the organizational context: The reality of resources and their consequences. *Annual Review of Organizational Psychology and Organizational Behavior*, 5, 103–128.
- Hofmann, D. A., Griffin, M., & Gavin, M. (2000). The application of hierarchical linear modeling to organizational research. In K. J. Klein, & S. W. J. Kozlowski (Eds.), *Multilevel theory, research, and methods in organizations* (pp. 467–511). San Francisco, CA: Jossey-Bass.
- Hopstaken, J. F., van der Linden, D., Bakker, A. B., & Kompier, M. A. (2015). A multifaceted investigation of the link between mental fatigue and task disengagement. *Psychophysiology*, 52(3), 305–315.
- Hightower, R. H., & Sayeed, L. (1995). The impact of computer-mediated communication systems on biased group discussion. *Computers in Human Behavior*, 11(1), 33–44.
- Hightower, R. H., & Sayeed, L. (1996). Effects of communication mode and prediscussion information distribution characteristics on information exchange in groups. *Information Systems Research*, 7(4), 451–465.
- Hinds, P., Liu, L., & Lyon, J. (2011). Putting the global in global work: An intercultural lens on the practice of cross-national collaboration. *The Academy of Management Annals*, 5(1), 135–188.
- Jap, S., Robertson, D. C., & Hamilton, R. (2011). The dark side of rapport: Agent misbehavior face-to-face and online. *Management Science*, 57(9), 1610–1622.
- Johnson, R. E., Lanaj, K., & Barnes, C. M. (2014). The good and bad of being fair: Effects of procedural and interpersonal justice behaviors on regulatory resources. *Journal of Applied Psychology*, 99(4), 635–650.
- Kahn, W. A. (1990). Psychological conditions of personal engagement and disengagement at work. *Academy of Management Journal*, 33(4), 692–724.
- Kahneman, D. (2003). A perspective on judgment and choice: Mapping bounded rationality. *American Psychologist*, 58(9), 697–720.
- Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology*, 15(3), 169–182.
- Kim, S., Park, Y., & Niu, Q. (2017). Micro-break activities at work to recover from daily work demands. *Journal of Organizational Behavior*, 38(1), 28–44.
- Kock, N. (2004). The psychobiological model: Towards a new theory of computer-mediated communication based on Darwinian evolution. *Organization Science*, 15(3), 327–348.
- Kock, N. (2007). Media naturalness and compensatory encoding: The burden of electronic media obstacles is on senders. *Decision Support Systems*, 44(1), 175–187.
- Koopman, J., Lanaj, K., & Scott, B. A. (2016). Integrating the bright and dark sides of OCB: A daily investigation of the benefits and costs of helping others. *Academy of Management Journal*, 59(2), 414–435.
- Kun, A., Sadun, R., Shaer, O., & Teodorovic, T. (2020). Where did the commute time go. In *Harvard business review*. Retrieved May 1, 2021, from <https://hbr.org/2020/12/where-did-the-commute-time-go>.
- Lanaj, K., Johnson, R. E., & Barnes, C. M. (2014). Beginning the workday yet already depleted? Consequences of late-night smartphone use and sleep. *Organizational Behavior and Human Decision Processes*, 124(1), 11–23.
- Levin, J. A., & Moore, J. A. (1977). Dialogue-games: Metacommunication structures for natural language interaction. *Cognitive Science*, 1(4), 395–420.
- Lilius, J. M. (2012). Recovery at work: Understanding the restorative side of “depleting” client interactions. *Academy of Management Review*, 37(4), 569–588.
- Lord, R. G., Diefendorff, J. M., Schmidt, A. M., & Hall, R. J. (2010). Self-regulation at work. *Annual Review of Psychology*, 61, 543–568.
- MacKinnon, D. P., Lockwood, C. M., & Williams, J. (2004). Confidence limits for the indirect effect: Distribution of the product and resampling methods. *Multivariate Behavioral Research*, 39(1), 99–128.
- Mazmanian, M. (2013). Avoiding the trap of constant connectivity: When congruent frames allow for heterogeneous practices. *Academy of Management Journal*, 56(5), 1225–1250.
- Mazmanian, M., Orlikowski, W. J., & Yates, J. (2013). The autonomy paradox: The implications of mobile email devices for knowledge professionals. *Organization Science*, 24(5), 1337–1357.
- McGinn, K. L., & Keros, A. T. (2002). Improvisation and the logic of exchange in socially embedded transactions. *Administrative Science Quarterly*, 47(3), 442–473.
- McGrath, J. E., & Hollingshead, A. B. (1994). *Groups interacting with technology: Ideas, evidence, issues, and an agenda*. Thousand Oaks, CA: Sage.
- McGregor, J. (2012). How much time you really spend emailing at work. The Washington Post (July 31). Retrieved May 1, 2021, from https://www.washingtonpost.com/blogs/post-leadership/post/how-much-time-you-really-spend-emailing-at-work/2012/07/31/gJQAI50sMX_blog.html?utm_term=.cdf0ee07125d.
- Mitchell, M. S., Greenbaum, R. L., Vogel, R. M., Mawritz, M. B., & Keating, D. J. (2019). Can you handle the pressure? The effect of performance pressure on stress appraisals, self-regulation, and behavior. *Academy of Management Journal*, 62(2), 531–552.
- Moller, A. C., Deci, E. L., & Ryan, R. M. (2006). Choice and ego-depletion: The moderating role of autonomy. *Personality and Social Psychology Bulletin*, 32(8), 1024–1036.
- Morgeson, F. P., & Humphrey, S. E. (2006). The work design questionnaire (WDQ): Developing and validating a comprehensive measure for assessing job design and the nature of work. *Journal of Applied Psychology*, 91(6), 1321–1339.
- Muthén, L. K., & Muthén, B. O. (2015). *Mplus user's guide* (7th ed.). Los Angeles, CA: Muthén & Muthén.
- Müller, T., & Apps, M. A. (2019). Motivational fatigue: A neurocognitive framework for the impact of effortful exertion on subsequent motivation. *Neuropsychologia*, 123, 141–151.
- Naquin, C. E., Kurtzberg, T. R., & Belkin, L. Y. (2010). The finer points of lying online: E-mail versus pen and paper. *Journal of Applied Psychology*, 95(2), 387–394.
- Neale, M. A., & Northcraft, G. B. (1990). Experience, expertise, and decision bias in negotiation: The role of strategic conceptualization. *Research on Negotiation in Organizations*, 2, 55–75.
- Okhuysen, G. A., & Bechky, B. A. (2009). 10 Coordination in organizations: An integrative perspective. *The Academy of Management Annals*, 3(1), 463–502.
- Peñarroja, V., Orengo, V., Zornoza, A., & Hernández, A. (2013). The effects of virtuality level on task-related collaborative behaviors: The mediating role of team trust. *Computers in Human Behavior*, 29(3), 967–974.
- Podsakoff, P. M., MacKenzie, S. B., & Podsakoff, N. P. (2012). Sources of method bias in social science research and recommendations on how to control it. *Annual Review of Psychology*, 63, 539–569.
- Postrel, S. (2002). Islands of shared knowledge: Specialization and mutual understanding in problem-solving teams. *Organization Science*, 13(3), 303–320.
- Preacher, K. J., Curran, P. J., & Bauer, D. J. (2006). Computational tools for probing interactions in multiple linear regression, multilevel modeling, and latent curve analysis. *Journal of Educational and Behavioral Statistics*, 31(4), 437–448.
- Purdy, J. M., Nye, P., & Balakrishnan, P. S. (2000). The impact of communication media on negotiation outcomes. *International Journal of Conflict Management*, 11(2), 162–187.
- Putnam, L. L. (1994). Challenging the assumptions of traditional approaches to negotiation. *Negotiation Journal*, 10(4), 337–346.
- Quinn, R. W., Spreitzer, G. M., & Lam, C. F. (2012). Building a sustainable model of human energy in organizations: Exploring the critical role of resources. *The Academy of Management Annals*, 6(1), 337–396.
- Radicati, S., & Hoang, Q. (2011, May). Email statistics report, 2011–2015. The Radicati Group. Retrieved May 1, 2021, from <http://www.radicati.com/wp/wp-content/uploads/2011/05/Email-Statistics-Report-2011-2015-Executive-Summary.pdf>.
- Raghuram, S., Hill, N. S., Gibbs, J. L., & Maruping, L. M. (2019). Virtual work: Bridging research clusters. *Academy of Management Annals*, 13(1), 308–341.
- Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods*. Sage.
- Raven, J. (1989). The Raven Progressive Matrices: A review of national norming studies and ethnic and socioeconomic variation within the United States. *Journal of Educational Measurement*, 21(1), 1–16.
- Raven, J. (2000). The Raven's progressive matrices: Change and stability over culture and time. *Cognitive Psychology*, 41(1), 1–48.
- Reyt, J. N., & Wiesenfeld, B. (2015). Seeing the forest for the trees: Exploratory learning, mobile technology, and knowledge workers' role integration behaviors. *Academy of Management Journal*, 58(3), 739–762.
- Rich, B. L., Lepine, J. A., & Crawford, E. R. (2010). Job engagement: Antecedents and effects on job performance. *Academy of Management Journal*, 53(3), 617–635.
- Richeson, J. A., & Shelton, J. N. (2003). When prejudice does not pay effects of interracial contact on executive function. *Psychological Science*, 14(3), 287–290.
- Richeson, J. A., & Trawalter, S. (2005). Why do interracial interactions impair executive function? A resource depletion account. *Journal of Personality and Social Psychology*, 88(6), 934–947.

- Rockmann, K. W., & Northcraft, G. B. (2008). To be or not to be trusted: The influence of media richness on defection and deception. *Organizational Behavior and Human Decision Processes*, 107(2), 106–122.
- Rosen, C. C., Simon, L. S., Gajendran, R. S., Johnson, R. E., Lee, H. W., & Lin, S. H. J. (2019). Boxed in by your inbox: Implications of daily e-mail demands for managers' leadership behaviors. *Journal of Applied Psychology*, 104(1), 19–33.
- Schwartz, T., & McCarthy, C. (2007). Manage your energy, not your time. *Harvard Business Review*, 85(10), 24–33.
- Selig, J. P., & Preacher, K. J. (2008). Monte Carlo method for assessing mediation: An interactive tool for creating confidence intervals for indirect effects [Computer software].
- Siemsen, E., Roth, A., & Oliveira, P. (2010). Common method bias in regression models with linear, quadratic, and interaction effects. *Organizational Research Methods*, 13(3), 456–476.
- Simmons, J. P., Nelson, L. D., & Simonsohn, U. (2011). False-positive psychology: Undisclosed flexibility in data collection and analysis allows presenting anything as significant. *Psychological Science*, 22(11), 1359–1366.
- Snijders, T., & Bosker, R. (1999). *Multilevel analysis: An introduction to basic and advanced multilevel modeling*. London, England: Sage.
- Sonnentag, S., & Zijlstra, F. R. (2006). Job characteristics and off-job activities as predictors of need for recovery, well-being, and fatigue. *Journal of Applied Psychology*, 91(2), 330–350.
- Spataro, J. (2021). Microsoft team reaches 115 million DAU – plus, a new daily collaboration minutes metric for Microsoft 365. Retrieved May 1, 2021, from <https://www.microsoft.com/en-us/microsoft-365/blog/2020/10/28/microsoft-teams-reaches-115-million-dau-plus-a-new-daily-collaboration-minutes-metric-for-microsoft-365/>.
- Srinivas, K., & Roediger, H. L. (1990). Classifying implicit memory tests: Category association and anagram solution. *Journal of Memory and Language*, 29(4), 389–412.
- Straub, D., & Karahanna, E. (1998). Knowledge worker communications and recipient availability: Toward a task closure explanation of media choice. *Organization Science*, 9(2), 160–175.
- Straus, S. G., & McGrath, J. E. (1994). Does the medium matter? The interaction of task type and technology on group performance and member reactions. *Journal of Applied Psychology*, 79(1), 87–97.
- Swaab, R. I., Galinsky, A. D., Medvec, V., & Diermeier, D. A. (2012). The communication orientation model explaining the diverse effects of sight, sound, and synchronicity on negotiation and group decision-making outcomes. *Personality and Social Psychology Review*, 16(1), 25–53.
- Tang, P. M., Yam, K. C., & Koopman, J. (2020). Feeling proud but guilty? Unpacking the paradoxical nature of unethical pro-organizational behavior. *Organizational Behavior and Human Decision Processes*, 160, 68–86.
- Tangirala, S., & Alge, B. J. (2006). Reactions to unfair events in computer-mediated groups: A test of uncertainty management theory. *Organizational Behavior and Human Decision Processes*, 100(1), 1–20.
- Tankovska, H. (2021). Email usage in the United States – Statistics & Facts. Retrieved May 6, 2021, from <https://www.statista.com/topics/4295/e-mail-usage-in-the-uni ted-states/#dossierSummary>.
- Toburen, T., & Meier, B. P. (2010). Priming God-related concepts increases anxiety and task persistence. *Journal of Social and Clinical Psychology*, 29(2), 127–143.
- Toplak, M. E., West, R. F., & Stanovich, K. E. (2013). Practitioner Review: Do performance-based measures and ratings of executive function assess the same construct? *Journal of Child Psychology and Psychiatry*, 54(2), 131–143.
- Twenge, J. M., Muraven, M., & Tice, D. M. (2004). *Measuring state self-control: Reliability, validity, and correlations with physical and psychological stress*. San Diego State University. Unpublished manuscript.
- Valacich, J. S., & Schwenk, C. (1995). Devil's advocacy and dialectical inquiry effects on face-to-face and computer-mediated group decision making. *Organizational Behavior and Human Decision Processes*, 63(2), 158–173.
- van der Linden, D., Frese, M., & Sonnentag, S. (2003). The impact of mental fatigue on exploration in a complex computer task: Rigidity and loss of systematic strategies. *Human Factors*, 45(3), 483–494.
- Walther, J. B. (1992). Interpersonal effects in computer-mediated interaction: A relational perspective. *Communication Research*, 19(1), 52–90.
- Walther, J. B. (2002). Time effects in computer-mediated groups: Past, present, and future. In P. Hinds, & S. Kiesler (Eds.), *Distributed work* (pp. 235–257). Cambridge, MA: MIT Press.
- Walther, J. B. (2015). Social Information Processing Theory (CMC). *The International Encyclopedia of Interpersonal Communication*, 1–13.
- Walther, J. B., Anderson, J. F., & Park, D. W. (1994). Interpersonal effects in computer-mediated interaction: A meta-analysis of social and antisocial communication. *Communication Research*, 21(4), 460–487.
- Waltz, J. A., Knowlton, B. J., Holyoak, K. J., Boone, K. B., Mishkin, F. S., de Menezes Santos, M., ... Miller, B. L. (1999). A system for relational reasoning in human prefrontal cortex. *Psychological Science*, 10(2), 119–125.
- Wanberg, C. R., Zhu, J., & Van Hooft, E. A. (2010). The job search grind: Perceived progress, self-reactions, and self-regulation of search effort. *Academy of Management Journal*, 53(4), 788–807.
- Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, 54(6), 1063–1070.
- Weber, R. A., & Camerer, C. F. (2003). Cultural conflict and merger failure: An experimental approach. *Management Science*, 49(4), 400–415.
- Weber, E. U., & Johnson, E. J. (2009). Mindful judgment and decision making. *Annual Review of Psychology*, 60, 53–85.
- Wiesenfeld, B. M., Raghuram, S., & Garud, R. (1999). Communication patterns as determinants of organizational identification in a virtual organization. *Organization Science*, 10(6), 777–790.
- Yates, J., & Orlikowski, W. J. (1992). Genres of organizational communication: A structural approach to studying communication and media. *Academy of Management Review*, 17(2), 299–326.
- Zijlstra, F. R., Roe, R. A., Leonora, A. B., & Krediet, I. (1999). Temporal factors in mental work: Effects of interrupted activities. *Journal of Occupational and Organizational Psychology*, 72(2), 163–185.