Global virtual team communication, coordination, and performance across three peer feedback strategies

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Abstract:

Global virtual teams (GVTs) are faced with numerous communication and coordination difficulties. This study examined whether peer feedback, implemented via a quasi-experiment, strengthened linkages between GVT communication, coordination, and performance. Drawing upon self-regulation as a critical mechanism underlying team effectiveness, we proposed a model in which the indirect relation between communication and performance, mediated by process coordination, would be stronger as peer feedback intensity increased. The effects of 3 feedback strategies were investigated: (a) feedback given and received only at project completion, (b) feedback given weekly, but not distributed until project completion, and (c) feedback given and received weekly. We examined this model using a large sample of GVTs (n = 1,839 teams; n = 13,224 individuals) and multilevel, multisource data. Results supported a stronger indirect effect between communication frequency and performance, via process coordination, when GVT members gave and received weekly feedback. These findings suggest GVTs should use structured peer feedback systems that allows giving and receiving regular feedback. Further implications for research and practice are considered.

Keywords: virtual teams | group processes | peer feedback | coordination | communication

Article:

> . . . the structural conditions that foster the effectiveness of face-to-face teams are just as critical for virtual teams-but with one caveat:
>
> *It is much harder to create those conditions in virtual teams.*
>
> -Hackman, 2002, p. 131; emphasis in original

As globalization and technological advances make it increasingly possible for workplace teams to transcend geographic and cultural divisions (Connaughton & Shuffler, 2007), global virtual teams (GVTs) are becoming ubiquitous. According to a recent survey of executives, 89% stated that they were a member of at least one GVT, and 88% believed that GVTs were critical for

completing daily tasks (RW3, 2018). However, despite their prevalence, GVTs can face numerous challenges (Gilson, Maynard, Young, Vartianinen, & Hakonen, 2015). Separation in time, space, language proficiency, and geography can weaken social connectedness and trust between members and can threaten effectiveness (Varty, O'Neill, & Hambley, 2017). The highly ambiguous environment of online collaboration, coupled with asynchronous communication can contribute to delays, frustration, and misunderstandings. Indeed, technology-mediated communication often lowers team decision-making effectiveness (Maynard & Gilson, 2014; O'Neill, Hancock, Zivkov, Larson, & Law, 2016) and can inhibit project progress (Driskell, Radtke, & Salas, 2003). Govindarajan and Gupta (2001) also suggested that communication barriers could lead to misalignment of individual members' activities and poor coordination of critical GVT resources and processes, strongly impacting the success and survival of a GVT.

consequently, for a GVT to meet its goals, and overcome these challenges, it is crucial that structure be introduced to the interactions between GVT members to enhance the coordination of critical resources among members and support GVT effectiveness (Govindarajan & Gupta, 2001; Hoch & Kozlowski, 2014; Lacerenza, Zajac, Savage, & Salas, 2015; Santistevan & Josserand, 2019). Structural support systems may assist GVTs in self-regulating their internal processes and can facilitate overcoming the challenges of technology-mediated communication (Humphrey & Aime, 2014). One structural support system that is promising is the inclusion of peer feedback (e.g., Espinosa, Nan, & Carmel, 2015; Lacerenza et al., 2015). Yet peer feedback in GVTs has been largely understudied. Specifically, the role peer feedback has for enhancing the links between team inputs, processes, and outcomes is currently unknown. Accordingly, we examined whether peer feedback influences the strength of the relations between communication frequency, process coordination, and performance in GVTs. This work, therefore, sheds new light on peer feedback as a means of providing crucial structural support for GVTs.

We begin by reviewing the role of peer feedback, and then describe the importance of communication frequency and coordination of intrateam GVT processes. Then, we revisit peer feedback and describe how it moderates the links between communication, coordination, and performance. Specifically, we discuss how a system that requests and delivers peer feedback on a regular basis more tightly links communication, process coordination, and GVT performance. Finally, we detail the study we conducted to investigate the role of peer feedback in GVTs.

Overview of Peer Feedback

Research on the benefits of intrateam feedback systems suggests that the inclusion of peer feedback might address the lack of organizing structure, a key challenge facing GVTs (Geister, Konradt, & Hertel, 2006). Peer feedback may enhance the goal directedness, mutual relevance, and timeliness of communication and coordinating activities and can introduce structure that would not be available otherwise. More specifically, a peer feedback system can help align individual members' behaviors through communicating mutual expectations (Brutus & Donia, 2010; Brutus, Donia, & Ronen, 2013; Donia, O'Neill, & Brutus, 2018). Likewise, given the challenges of, and need for, creating an organizing structure in a highly ambiguous online environment, peer feedback may be essential for GVT effectiveness and likely fosters teams' long-term development (Lacerenza et al., 2015). In other words, peer feedback may reduce the communication and collaboration challenges GVTs face. Despite its likely positive impact, the

influence of peer feedback on the links between communication, coordination, and effectiveness in GVTs has yet to receive sufficient research attention. Existing research has predominantly been conducted in lab settings (e.g., Breuer, Hüffmeier, & Hertel, 2016) or in teams operating regionally (Geister et al., 2006), limiting the implications and recommendations available for teams that must interact across geographic, cultural, and time-zone boundaries. Thus, there is a crucial need for research to investigate whether the structural supports offered by peer feedback provide optimized conditions for GVTs engaged in a long-term project. As such, we used a cluster randomized quasi-experiment to vary the intensity of peer feedback to examine how peer feedback strengthens the links between communication frequency, process coordination, and GVT effectiveness (see Figure 1).

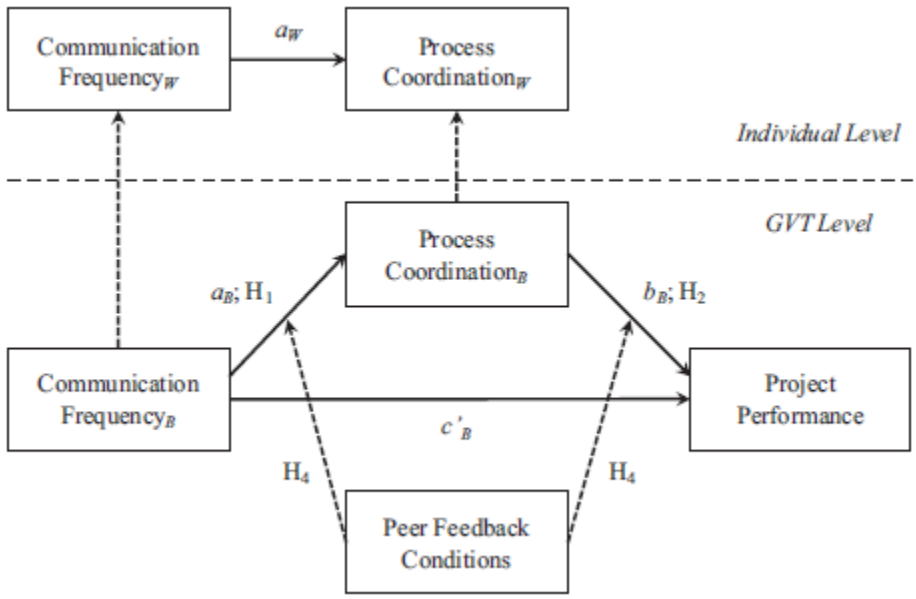

Figure 1. General conceptual model forwarded by this study. Pathways labelled as in traditional mediation models, with subscripts denoting within-level, *W*, and between-level, *B*, linkages. Hypotheses 1 and 2 labelled by H_1 and H_2, respectively. Hypothesis 3 posited an indirect mediation effect of communication frequency → process coordination → team performance and was tested by $a_B \times b_B$. Hypothesis 4 posited moderated mediation in that the indirect effect varied across levels of peer feedback.

Communication Frequency and Process Coordination

One of the key antecedents of GVT effectiveness (as well as for in-person teams) is communication frequency (Connaughton & Shuffler, 2007; Espinosa, Slaughter, Kraut, & Herbsleb, 2007; Jarvenpaa & Leidner, 1999; Rousseau, Aubé, & Savoie, 2006). For instance, Cummings, Espinosa, and Pickering (2009) found that frequent communication was related to fewer coordination delays and suggested that infrequent communication slows team progress, particularly when the team requires high interdependence. However, frequent communication is challenging in GVTs due to the separation of members across cultures and time-zones. As a result, coordination can be difficult (Govindarajan & Gupta, 2001; Santistevan & Josserand, 2019; Zakaria, 2017). Without frequent communication, team members may be "flying blind"

with respect to the activities, behaviors, and challenges faced by other members and can result in weaker integration of individuals' efforts and accomplishments. Therefore,

> *Hypothesis 1:* Communication frequency will be positively related to process coordination.[1]

Process Coordination and Performance

Researchers have historically viewed process coordination as the "black box" through which team inputs are transformed into team outputs (Espinosa et al., 2015). For example, Hackman (1987) placed "group interaction processes" between inputs (i.e., individual- and group-level resources) and outputs (e.g., performance). This emphasizes the input-process-output (IPO) model and the critical role intrateam processes have for transforming team inputs into outputs (Marks, Mathieu, & Zaccaro, 2001). Ilgen, Hollenbeck, Johnson, and Jundt (2005) extended the IPO model to include a feedback cycle in which outputs inform subsequent IPO episodes, suggesting an input-mediator-output-input (IMOI) model. We draw upon the IPO and IMOI models, not to pit them against each other, but to use them as organizing frameworks that provide theoretical lenses for how peer feedback can enhance the links between communication frequency, process coordination, and GVT effectiveness (described further below).

Kozlowski and Ilgen (2006) noted that a "dynamic, shifting, and complex environment (typical of those in which GVTs operate) creates commensurate team task demands that members have to resolve through a coordinated process" to generate team outcomes (p. 78, emphasis in original). Process coordination reflects the sequence, timing, and integration of individual members' work into an interdependent whole and represents the critical mechanisms that convert team resources into team performance (Humphrey & Aime, 2014). Process coordination has been regarded as one of the most crucial teamwork components (Kozlowski & Ilgen, 2006), and that coordination difficulties can lead to poor performance outcomes (Gevers & Peeters, 2009). In this research, we treat process coordination as the combined influence of communication smoothness, workflow integration, project planning, and role clarity.

Process coordination is particularly critical to gvts, as use of electronic communication creates challenges for adequate communication (Kirkman, Rosen, Gibson, Tesluk, & McPherson, 2002). Weak process coordination likely occurs as GVT members must transmit complex information through relatively lean media (i.e., sending an e-mail vs. meeting face-to-face; Espinosa et al., 2015), which may be further complicated when members receive insufficient responses, or when messages are delayed or misinterpreted. Thus, teams that have weaker process coordination are unlikely to perform well, and that this negative relation may be particularly impactful in GVTs because they experience greater barriers to achieving process coordination, particularly in

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[1] To obtain as unbiased estimates as possible, it is appropriate to control for the role of geographic dispersion among GVT members. Following recent advances in the methodological literature (O'Neill, McLarnon, Schneider, & Gardner, 2014), we wished to explicitly incorporate this control variable. Given that GVTs varied in geographic dispersion and that electronic communication frequency and geographic dispersion tend to be used as indicators of virtuality (Bell & Kozlowski, 2002; Breuer et al., 2016; Hoch & Kozlowski, 2014), controlling for the latter was important. As well, in a supplemental model we included team size, proportion of women on each team, average and the standard deviation of English fluency, and previous international experience as additional covariates. There were no substantive differences for results of the moderated indirect effects model with these additional covariates.

situations that require highly interdependent work activities (Bell & Kozlowski, 2002; Rico & Cohen, 2005). Thus,

> *Hypothesis 2:* Process coordination will be positively related to GVT performance.

Electronic Communication, Process Coordination, and Performance

Communication norms tend to emerge early in a team's lifecycle (e.g., Hackman & Morris, 1975; Kanawattanachai & Yoo, 2007; Zakaria, 2017), whereas coordination takes time to develop (Kozlowski, Gully, Nason, & Smith, 1999). This suggests that communication precedes process coordination. Further, early communication may influence effectiveness by improving the functioning of intrateam processes (Crisp & Jarvenpaa, 2013), implying a mediated path in which intrateam processes transmit the effects of communication frequency. As such, in GVTs that communicate often, high process coordination is likely, resulting in higher performance. Together, communication influences performance indirectly via process coordination. Thus,

> *Hypothesis 3:* Process coordination will mediate the communication frequency to performance relation.

Peer Feedback in GVTs

We next propose that the indirect effect of communication frequency on performance, transmitted via process coordination, will be moderated by the intensity of peer feedback. Feedback can focus GVT members' attention on his or her role and responsibilities, inform individuals when his or her behavior moves away from the team goal, and promotes learning from past performance episodes (Açıkgöz & Latham, 2018; Hattie & Timperley, 2007). Feedback, in short, enables self-regulation, focusing GVT members' awareness on potential discrepancies between individual behavior and team goals (DeShon, Kozlowski, Schmidt, Milner, & Wiechmann, 2004). Feedback from one's peers, and its role in activating self-regulation, likely strengthens the links between communication frequency, coordination, and effectiveness.

Self-regulation is integral to several models of team effectiveness, which denote that knowledge of past performance episodes is critical for impacting future performance. In these models, past performance outputs influence subsequent motivational states and the processes underlying future performance (i.e., reflecting a feedback loop or cycle; Chen & Kanfer, 2006; DeShon et al., 2004; Ilgen et al., 2005; Mathieu, Maynard, Rapp, & Gilson, 2008; Van Hooft & Van Mierlo, 2018). In alignment with the IMOI model, this self-regulation cycle is activated by peer feedback (Donia et al., 2018), because peers can provide insight into the gaps between a member's performance and the expectations of the team. Without self-regulation, the likelihood that individuals will adjust their behavior to correspond with the requirements of the team is weakened. Peer feedback activates self-regulation because peers provide an external comparison for performance, which functions as the basis upon which to adjust one's behavior. Conversely, the IPO model does not describe the functioning of feedback loops or temporal dynamics well (see Mathieu, Tannenbaum, Donsbach, & Alliger, 2014) and often reflects a single, time-limited

performance episode that may not afford the opportunity for learning or behavioral adjustments, which are likely required in long-term collaborative projects that have multiple subcomponents.

Van Hooft and Van Mierlo (2018) also noted that self-regulation may function to strengthen the linkages between team inputs and outputs as it enhances goal-striving, and team-directed behaviors such as planning, effort, reflexivity, and strategizing (chen & Kanfer, 2006). Thus, self-regulation, enabled through increasing the availability of peer feedback information, may moderate the indirect effect of the communication frequency → process coordination → performance link. For example, consider receiving feedback from one's teammates along the lines of "You should respond to messages more promptly, so we know what you're working on," and/or "You duplicated a lot of what I did, so we wasted a lot of time." Without hearing from one's GVT peers through a formal, structured system that one is not communicating enough, or what they are working on is not relevant to the team's goals, there will be little opportunity for an individual to change and improve for the next performance episode. The insight made available from one's GVT peers can help activate self-regulatory mechanisms and function to more tightly link relations between communication frequency and process coordination, and process coordination and team performance. Without gaining insight into how one's teammates have perceived past actions and behavior, self-regulatory functioning might not be activated, resulting in suboptimal motivation and performance. In other words, without information from one's teammates, an individual will be less likely to correct his or her behaviors, resulting in weaker overall team performance. In addition, more regular feedback may further enhance self-regulation and function as a stronger structural support for GVTs, such that individuals will be able to adjust their behavior in a timelier fashion with more regular feedback.

The Moderating Role of Peer Feedback: Three Different Strategies

To assess the role of peer feedback, we manipulated three feedback strategies that varied the intensity and regularity of feedback: (a) low intensity feedback, where feedback was only given and received at the conclusion of the GVT's project; (b) moderate intensity feedback, in which feedback was given regularly, but not distributed until project completion, and (c) high intensity feedback, in which feedback was given and received at regular intervals throughout the project. Low intensity feedback, which we refer to as the postproject only feedback strategy, reflects a common method of using feedback in teams (e.g., O'Neill, McLarnon, Hoffart, Onen, & Rosehart, 2018; Smither, London, & Reilly, 2005), and would be typical of the "annual review" used in many organizational environments. Postproject only feedback would also most strongly reflect the functioning of the IPO model, where individuals' ongoing performance would not be easily influenced by previous behavior, such that fewer behavioral adjustments likely occur.

Moderate intensity feedback, which we refer to as the weekly exposure feedback strategy, requested weekly feedback from each GVT member about each of their peers, but the feedback was not distributed until the end of the project. High intensity feedback, hereafter referred to as the weekly distribution feedback strategy, requested and distributed the feedback from one's GVT peers on a weekly basis. Dominick, Reilly, and McGourty (1997) compared the effects of giving and receiving feedback to only giving feedback (and vs. a control condition in which no feedback was exchanged). Although they found that effectiveness increased in both feedback conditions versus the control, differences across the feedback conditions did not emerge,

suggesting that it would be sufficient to only give (rather than also receive) feedback. However, Dominick et al. (1997) used only a single round of feedback, whereas Donia et al.'s (2018) results indicated that multiple rounds of feedback are needed. A single round of feedback would more strongly reflect the IPO model, rather than the IMOI model. As well, only providing feedback, but not receiving any, unlikely prompts self-regulation, or the cycle of outputs to inputs, described by the IMOI model. Peer feedback that is given and received at regular intervals throughout a project more likely facilitates learning and behavior modification through the activation and functioning of self-regulation. Moreover, multiple rounds of feedback would be needed to give GVT members multiple opportunities to adjust their behavior to potentially evolving team goals. Accordingly, giving and receiving, rather than just giving feedback represents increases in the regularity, structure, and intensity of peer feedback.

We expect that more intense peer feedback will create a more tightly coupled indirect effect between communication frequency and GVT performance, as transmitted by process coordination. Specifically, peer feedback can give each GVT member greater insight into the roles, responsibilities, and workload of other members. communication may then become more focused on supporting other members in their roles, making individual behaviors more relevant to overall coordination (i.e., monitoring and backup behaviors; Marks et al., 2001). Thus, regularity of peer feedback should strengthen the relation between communication frequency and process coordination.

As for the process coordination → performance relation, peer feedback should more strongly coordinate individual behaviors and orient GVT members to the actions of the other members. For this relation, feedback would address the potential for members to be working in a coordinated fashion, but not working toward achieving the team's most vital goals. Intense peer feedback may therefore increase the likelihood that critical issues are addressed by coordinating the right task activities, and that each member's individual activities are more highly aligned for the purpose of benefitting overall GVT effectiveness. Together, a high intensity feedback strategy will create a more tightly coupled indirect effect involving communication frequency → process coordination → GVT performance. Thus,

> *Hypothesis 4:* Peer feedback moderates the indirect effect of communication frequency on performance, as mediated by process coordination, such that increasing peer feedback intensity increases the strength of the indirect effect.

Method

Participants and Procedure

The data for this study were obtained using a sample of 13,224 individuals who were participating in the X-Culture international consulting competition (Taras, Caprar, & Huang, 2013) and were randomly assigned to be members of 1,839 GVTs. X-Culture is an international business case competition involving students from over 100 universities in 40 countries. Participants were 48% men and 45% women (7% did not declare gender) and were on average 22.3 years old (SD = 6.1). The majority were undergraduate students (72%), with the remainder master's or MBA students. This study used the data from 2011-2015 semesters of X-Culture.

Every semester, about a dozen companies present a challenge for the competition. Working in GVTs of about seven individuals, students spend a semester developing their solutions to those challenges.

X-Culture projects are designed to closely resemble the environment corporate GVTs function in. First, the international and virtual aspects of X-Culture are not simulated but are real. X-Culture GVT members are located in different countries and work across time-zone and cultural differences and must rely on online tools for communication. Second, the work design is very similar to that of real-world GVTs. The tasks are presented by real companies that request help with developing a market expansion strategy that includes an assessment of competing firms, selecting the most promising markets, assessing trade regulations, advising optimal pricing, marketing, human resources, logistics, and certification of products in the proposed market. Students work closely with their clients and have regular online meetings with client representatives. Importantly, X-Culture projects are not short inclass simulations, but last about 10 weeks during which GVT members interact on a regular basis and also includes about a month of preproject preparation and post-project presentations and debriefing sessions.

X-Culture participants are incentivized to demonstrate strong performance. Generally, the X-Culture project accounts for at least 30% of individuals' course grade, depending on their home university. In addition, the best GVTs are invited to the annual X-Culture Symposium, and the best students often receive internship or job offers from their clients. As well, most clients offer aftermarket commissions based on implementation of GVTs' projects.

Almost all participants had at least some work experience (~3.2 years), and many were currently employed (31.1%). These demographic characteristics suggest no threat to validity of the findings we offer. Most students participate in X-Culture as part of an International Business course, and typically each student in a participating course must participate in X-Culture. Just as employees are assigned to team projects, students are assigned to participate in X-Culture once they enroll in their home-university course, reducing concerns of selection bias. As X-Culture was designed to evolve each semester, the different peer feedback strategies were investigated in different semesters. This allowed us to test the effects of peer feedback intensity, in which the different peer feedback strategies reflect different conditions of a natural, cluster randomized quasi-experiment. Each cohort of X-Culture GVTs were engaged on similar client problems, had the same timeline, were offered similar incentives, and completed the same surveys during the project. Assignment to the experimental conditions was effectively random, as the students, once enrolled, were subjected to the peer feedback strategy in use in a particular semester.

Peer feedback strategies.

We manipulated three levels of peer feedback. In the postproject feedback only strategy, feedback was only obtained and distributed at the completion of the GVT project. We treated this as the baseline because it involved minimal exposure to the peer feedback process yet reflects typical feedback environments (Smither et al., 2005). In the weekly exposure strategy, peer ratings were measured weekly throughout the team's life span but were only distributed at project completion, thus only exposing members to the process of providing feedback. Although this represents an increase in intensity of feedback, without actually distributing the feedback the

self-regulatory cycle of behavioral outputs influencing subsequent performance episodes is unlikely to be activated. This strategy helps to rule out whether only being evaluated regularly was associated with the benefits of feedback (see above). In the weekly distribution strategy, feedback was obtained on a weekly basis but, critically, was also disseminated to each individual weekly. This reflects a combination of exposure to the feedback process, along with gaining insight into the evaluations from others. Therefore, this strategy best reflects the functioning of a self-regulatory cycle in which previous performance episodes can be used as a basis to adapt and adjust behavior for subsequent performance episodes and offers a further increase in intensity of peer feedback.

Regardless of strategy used, feedback was distributed anonymously, and solicited about the same behavioral dimensions (i.e., engagement, effort, intellectual contribution, and collegiality). The only aspect of peer feedback that differed was the intensity and frequency with which feedback was solicited, and when it was distributed. Postproject feedback only comprised 4,382 individuals and 814 GVTs. The weekly exposure strategy involved 6,813 individuals and 1,187 GVTs. The weekly distribution feedback strategy included 2,029 individuals and 368 GVTs. Demographics did not differ markedly across peer feedback strategies.

Measures

Every week, participants submitted a set of deliverables pertaining to their project and completed a survey that included peer evaluations (in the weekly exposure and weekly distribution strategies), intrateam interactions, and team-related attitudes and perceptions.

Communication frequency.

We assessed communication frequency with three items, adapted from Webster and Wong (2008). A sample item is "How many messages would you say you exchanged with your teammates over the course of the entire project?" Items were z-scored and averaged to compute an overall score.

Process coordination.

Process coordination measures vary widely according to the nature of the teamwork involved (Marks et al., 2001). As such, we adapted four items from Maynard, Mathieu, Rapp, and Gilson (2012) and Mathieu and Marks (2006) to tap into four critical coordination processes: communication smoothness, workflow integration, project planning, and role clarity. The first item assessed the degree to which barriers to effective collaboration were encountered during the team's lifecycle. Responses, which were reverse-coded, were made on a scale of 1 (no problem) to 5 (big problem). The second item, "How did your team distribute the workload among its members?" assessed workflow integration. Responses to this item were made on a 3-point scale, anchored at 1 ("We did not have a formal agreement about who would be doing what, we just did what we could, when we could") to 3 ("Every team member was assigned a specific function (e.g., some of us searched for data and literature, others were responsible for writing the report, some were responsible for coordinating our efforts, etc."). The third item, "Did your team set a formal schedule, such that the members had deadlines they had to meet?" assessed project

planning. A 3-point scale was used, ranging from 1 ("We did not set a schedule or deadlines for when each task had to be completed") to 3 ("We had a formal schedule and deadlines for when each task had to be completed"). Role clarity was assessed by: "Did you know exactly what you were supposed to do and when you were supposed to complete your tasks?" Responses were made on a 5-point scale anchored at 1 ("I never knew what I was supposed to do") to 5 ("I had a very clear idea as to what I had to do and when I had to complete my part"). Because of differing response scales, items were z-scored then averaged to create an overall score.

Project performance.

At the end of the semester, each team submitted a report detailing their proposed solution to the business challenge. GVT performance was assessed by the quality of the final report. Each report contained an overview of the client's products and competition, market research and analysis, proposed market entry strategies, financing, staffing, and product promotion. Each report was independently evaluated by five to seven experts (international business professors and client representatives) and was graded on viability, innovation, clarity, thoroughness, and overall quality. Ratings used a 7-point scale, anchored by 1 (very low quality) and 7 (excellent). We averaged across dimensions and evaluators to derive an overall score.

Control variable.

We controlled for geographic dispersion due to its association with communication frequency in a broader virtuality construct, which often reflects both virtual teams' communication frequency and geographical dispersion (see Hoch & Kozlowski, 2014). Following Suh and Shin (2010), geographic dispersion was calculated as the sum of distances (in miles) between each dyadic combination of GVT members.

Analytical Procedure

Psychometric properties and aggregation considerations.

As communication frequency and process coordination were composed of team- and individual-level variance (Lüdtke et al., 2008) we assessed reliability using Geldhof, Preacher, and Zyphur's (2014) multilevel approach. Table 1 presents reliability and intraclass correlation (ICC) estimates.

Table 1. Reliability and Aggregation Statistics

Variable	ICC(1)	ICC(2)	α
Communication frequency	.20	.60	.81
Process coordination	.20	.60	.72
Project performance	.48	—	.89

Note. ICC = intraclass correlation.

Modelling strategy.

Prior to estimating our focal model (see Figure 1), we examined measurement invariance to ensure meaningful comparisons across peer feedback strategies (see Flora & Flake, 2017).

Invariance analyses were based on the recommendations of Kim and Cao (2015; see also McLarnon & Carswell, 2013; Vandenberg & Lance, 2000). Three invariance analyses were needed: (a) configural, (b) metric, and (c) strong. Changes in the comparative fit index (CFI) < .010 and/or changes in the root mean square error of approximation (RMSEA) < .015 are supportive of invariance at each step (Chen, 2007).

Our model is an extension of a 1-1-2 multilevel mediation model (predictor and mediator at Level 1; criterion at Level 2; Preacher, Zyphur, & Zhang, 2010; see Figure 1). Instead of aggregating our data to the team-level, we used multilevel path analysis[2] to model only the reliable portions of the multilevel variables (Lüdtke et al., 2008). We examined moderation using a multigroup approach to compare the indirect effects across peer feedback strategies (see Chan, 2007). Together, our model reflects a multilevel moderated indirect effects model. We used 95% Monte Carlo confidence intervals (MC CIs) to assess significance of indirect effects within, and across peer feedback strategies (i.e., ak X bk, where k gives indirect effects that vary across strategies; Lachowicz, Sterba, & Preacher, 2015). Effect size of the indirect effects was assessed with κ2 and PM, the ratio of the indirect effect to total effect (Preacher & Kelley, 2011). PM has advantages over κ2 (Wen & Fan, 2015), but we report κ2 as it can be interpreted using Paterson, Harms, Steel, and Credé's (2016) recommendations (see also Preacher & Kelley, 2011).

Results

Table 2 contains the correlation matrices across feedback strategies. Interestingly, geographic dispersion had very low relations with our focal variables, and thus it does not appear to impact GVT processes and effectiveness (see Hoch & Kozlowski, 2014). However, we present results that include geographic dispersion, but no substantive differences emerged if it was excluded (see Endnote 1). Expecting that the communication frequency, process coordination, and performance relations would vary across strategies, we investigated measurement invariance across feedback strategies. Table 3 presents the multilevel measurement invariance results. Changes in the CFI and the RMSEA supported metric and strong invariance, suggesting that the measures functioned equivalently across peer feedback strategies, thereby facilitating cross-strategy comparisons, as needed for our moderated mediation model.

Hypothesis 1 posited that communication frequency would be positively related to process coordination, was not supported, b = .10, p = .13. This suggests that, across feedback strategies, there was no significant association between communication frequency and the coordination of GVTs' intrateam processes. Hypothesis 2 proposed that process coordination and performance would be positively related. This was supported, b = .57, p < .05. Therefore, GVTs that have greater process coordination also had higher performance. Hypothesis 3 proposed that process coordination mediates the relation between communication frequency and performance. Across peer feedback strategies, the indirect effect was .06 (95% MC CI = -.02-.14). Thus, there was no evidence of an indirect effect, collapsing across peer feedback strategies.

[2] Note, that project performance and geographical dispersion were team-level only variables that had no individual-level variability.

Table 2. Intercorrelation Matrices of Study Variables

Variable	1	2	3	4
Post project-only feedback				
1. Geographic dispersion	—			
2. Communication frequency	.43**	—	.01	
3. Process coordination	.06	–.09**	—	
4. Project performance	.19**	.32**	–.06	—
Weekly exposure to peer feedback system				
1. Geographic dispersion	—			
2. Communication frequency	–.31**	—	.14**	
3. Process coordination	–.09**	.07**	—	
4. Project performance	–.03	.12**	.34**	—
Weekly distribution of peer feedback				
1. Geographic dispersion	—			
2. Communication frequency	–.34**	—	.23**	
3. Process coordination	–.09	.43**	—	
4. Project performance	–.08	.27**	.46**	—

Note. Correlations above diagonal reflect individual-level estimates. Correlations below the diagonal reflect global virtual team (GVT)-level estimates. Whole sample *n*s = 13,224 individuals and *n* = 2,369 GVTs. Postproject only feedback, *n* = 4,382 individuals and *n* = 814 GVTs. Weekly exposure, *n* = 6,813 individuals and *n* = 1,187 GVTs. Weekly distribution, *n* = 2,029 individuals; *n* = 368 GVTs.
** $p < .01$.

Table 3. Multilevel Measurement Invariance Analyses

Invariance analysis	χ^2	χ^2c	χ^2 *df*	#fp	CFI	RMSEA	$\Delta\chi^2$	Δ*df*	ΔCFI	ΔRMSEA
Configural	2,447.17***	.86	306	198	.95	.04	—	—	—	—
Metric	2,491.93***	.92	342	162	.95	.04	129.65***	36	–.001	–.002
Strong	2,649.30***	.93	360	144	.95	.04	152.29***	18	–.003	.000

Note. χ^2c = scaling correction factor; *df* = degrees of freedom; #fp = number of parameters estimated; CFI = comparative fit index; RMSEA = root mean square error of approximation; $\Delta\chi^2$ = Satorra-Bentler scaled χ^2 difference statistic; Δ*df* = degrees of freedom; ΔCFI = change in CFI estimate from less restricted to more restricted models; ΔRMSEA = change in RMSEA estimate.
*** $p < .001$.

Hypothesis 4, however, proposed that peer feedback intensity moderates the strength of the indirect effects. In the post-project feedback only strategy, neither the relations between communication frequency and process coordination or process coordination and performance were significant, b = -.12, p = .29, and -.03, p = .45, respectively, resulting in an indirect effect, of .003, 95% MC CI = - .01-.02. In the weekly exposure strategy, the relation between communication frequency and process coordination was not significant, b = .06, p = .12, but the process coordination and performance relation was, b = .83, p < .01. However, the indirect effect, ab = .05, included zero in its 95% MC CI (- .01-.12). In the weekly distribution strategy, both paths between communication frequency and process coordination and performance were significant, b = .43, p < .01, and 1.02, p < .01, respectively. The indirect effect in the weekly distribution strategy was also significant, ab = .44, 95% MC CI = .12-.81.

To investigate moderation, differences in the strength of the indirect effects were assessed using 95% MC CIs (see Lachowicz et al., 2015). The difference between the mediated effects in post-project feedback only and weekly exposure strategies was .05, but as the 95% MC CI (-.02-.12)

included zero, they were not significantly different. Weekly distribution, however, had stronger indirect effects than both post-project feedback and weekly exposure, .43 (95% MC CI = .12-.81) and .38 (95% MC CI = .06-.77), respectively. Thus, Hypothesis 4 was supported: peer feedback that was collected and distributed regularly strengthens the indirect effect of communication frequency → process coordination → GVT effectiveness.

Considering effect sizes of the indirect effect, in the post-project feedback only strategy, PM = -.01 and κ2 = .00, suggesting a negligible effect. In the weekly exposure strategy, PM = .20 and κ2 = .02, also suggesting a trivial effect. However, in the weekly distribution strategy, PM = .75 and κ2 = .11, suggesting a moderate effect[3] (see Paterson et al., 2016), further supporting Hypothesis 4. Thus, when feedback is solicited and distributed regularly, process coordination transmits the effect of increased communication on GVT performance in terms of a statistically and practically significant indirect effect.

Discussion

GVTs are prevalent in today's organizations, yet little is known about this relatively new form of teamwork, and in particular about the role of peer feedback. Using a large sample of GVTs, we investigated the role of different peer feedback strategies on communication frequency, process coordination, and performance. The major contribution of this research is that intensity of peer feedback can strengthen the indirect effect between communication frequency and GVT performance, as mediated by process coordination. Thus, regularly providing and receiving feedback is key for enhancing and optimizing the links between communication frequency, process coordination, and performance, and increases the likelihood that a GVT meets its critical objectives through communication and coordination.

Contributions of Current Research

This study is novel in several respects. First, although past research has considered the influence of peer feedback in virtual team contexts, these teams were regional or ad hoc in nature. Regional virtual teams (e.g., Geister et al., 2006) are less likely to suffer from cultural, language, and/or time zone challenges compared to GVTs, which were the focus of the current research. Real-world GVTs also differ from ad hoc teams (i.e., those based in a laboratory environment) because GVTs are longer-term and are tasked with completing high-stakes, complex projects in less controlled environments (e.g., Weisband & Atwater, 1999). Second, existing research involves case studies (e.g., Jarvenpaa & Leidner, 1999), which can inform theory, but may not allow for generalization. In the present study, we used a large sample of GVTs, engaged in an intensive, long-term project, facilitating more generalizable findings. Third, other research has considered the role of feedback in virtual teams from a theoretical perspective only (e.g., Dennis & Valacich, 1999). Although this can inform conceptual underpinnings, large-scale empirical examinations are critical for knowledge development and informing practical recommendations.

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[3] Lachowicz (2017) proposed a further alternative mediation effect size measure to PM and κ2, which is called upsilon, e. Tools to estimate e are available in the MBESS package for R. However, e is not yet available for multilevel mediation models. To be thorough, we computed e using aggregated data for each strategy and found that the pattern of effect sizes does not differ appreciably from those given by PM and κ2: post-project only feedback e < .004, weekly exposure e = .003, and weekly distribution e = 1.607.

Fourth, whereas past research has proposed links between communication and coordination in virtual teams (e.g., Hambley, O'Neill, & Kline, 2007), this work has not also systematically manipulated peer feedback to investigate the combined influences on team effectiveness. Fifth, whereas Dominick et al. (1997) manipulated whether feedback was received or not, they did not consider repeated episodes of feedback. As such, we incorporated the basic manipulation of Dominick et al. (1997), but expanded on it by featuring multiple opportunities for GVT members to give and receive feedback.

Our results add to the foundational concepts of peer feedback reported previously (e.g., Dominick et al., 1997; Geister et al., 2006). Specifically, this study denotes the importance of the timeliness of feedback in influencing subsequent performance episodes (cf. Hattie & Timperley, 2007). It is not enough to give feedback on a regular basis. Instead, GVT members need to regularly receive feedback too. Feedback must be received regularly, in a timely manner to engage self-regulation, such that knowledge from previous performance episodes can influence subsequent behavior. Although not explicitly functioning as the linkage between output to input of the IMOI model, a structured system to give and receive peer feedback provides the information GVT members require to self-regulate their behavior and collaborate effectively to achieve the team's goals. Increasingly frequent, intense, and structured peer feedback, underscoring the role of self-regulation, functioned to increase the strength of the relations between GVTs communication frequency, the internal coordination of team processes, and team performance. Thus, as a contribution to the theory and literature around GVT functioning, the timing and intensity of peer feedback should be considered as a crucial lever that can strengthen the relations between the variables of an integrated model of GVT performance that links team and individual inputs and resources to coordination, and coordination to performance.

Process Coordination Enhances GVT Performance

This study further contributes to the GVT literature by examining process coordination and its indirect role between communication frequency and performance. The results of this study critically extend existing knowledge to highlight the importance of strong process coordination as an antecedent of GVT effectiveness. In terms of decision-making, process coordination concerns how teams manage the logistical components of achieving the team's goals, and how to coordinate individual members' specific efforts (Marks et al., 2001). If team decisions are not agreed upon, members may not complete their assigned tasks, or even "free ride." Further, as the electronic context in which GVTs operate is associated with reduced nonverbal cues, overall information sharing and mutual knowledge acquisition can be hindered, reducing the probability of effective coordination (Driskell et al., 2003). Accordingly, GVTs are likely at greater risk of ineffective process coordination and, in turn, performance as compared to traditional teams. Our results suggest that implementing regular peer feedback may more tightly couple coordination to performance. Thus, with regular and intense feedback, GVT members will be more coordinated and will function in a more collaborative, interdependent manner, working effectively toward accomplishing the GVT's strategic goals.

Communication Frequency Supports Process Coordination With Intense Peer Feedback

We had proposed that communication frequency would be positively related to process coordination, but it appears that without the structure provided by peer feedback, this relation was not supported. Further, our results suggest that increased communication is necessary but not sufficient for enhancing process coordination. In this research, we revealed a boundary condition of this relation, such that a positive relation between communication frequency and process coordination emerged only when combined with regular peer feedback. In other words, only when feedback is collected and shared on a weekly basis does a significant, positive relation between communication frequency and process coordination emerge. Accordingly, increased communication must be coupled with regular peer feedback. Regular feedback may ensure that messages transmitted are focused on the most important issues hindering coordination. In line with self-regulation, this benefit is likely due to increased attention on the behaviors necessary for GVT effectiveness, which are spurred by receiving regular feedback. Thus, to support intrateam communication and impact the coordination of GVT processes, consistently providing and receiving feedback from other GVT members is helpful.

Peer Feedback and Team Goal Attainment

We also posited that increasing peer feedback information would moderate the indirect relation between communication frequency, process coordination, and GVT effectiveness. Feedback, operating in line with self-regulation, can increase awareness of one's progression toward, or regression away from, a goal, and can also inform judgments regarding the level of effort required to achieve a goal, thereby playing a motivational role (DeShon et al., 2004; Donia et al., 2018). Recommendations extrapolated from the motivation literature suggest that team projects should be divided into a series of sequential subgoals (Steel & König, 2006). Frequently delivered feedback is essential in this case so that the team and its members are aware of whether they are achieving these subgoals, such that performance on previous subgoals can be used to inform progression toward subsequent performance episodes and subgoals. Receiving feedback can direct attention toward potential gaps between actual performance and the team's goals (see Hattie & Timperley, 2007). As we reported, both the pathways between communication frequency and process coordination, and process coordination and performance are significantly stronger when regular feedback was delivered and received in a timely manner. Stemming from this research, our results contribute to theory generation in that the benefits of added communication are only realized when feedback is obtained and delivered in a timely manner. If feedback does not occur on a consistent, ongoing basis, then the recipient may not fully benefit from the insight available from one's GVT peers.

Practical Implications

Our findings inform several practical recommendations that can improve GVT processes and effectiveness. Specifically, GVTs should be encouraged to communicate frequently. As well, integrating our findings with those of previous research, multiple communication modes should be made available to GVTs (Govindarajan & Gupta, 2001), and that members should receive adequate training on each communication tool (Lacerenza et al., 2015). However, communication does not directly influence performance, but rather operates through improved coordination. This of course comes with a caveat: Unless GVTs are operating in a setting that offers opportunities to give and receive peer feedback, the benefits of enhanced links between

communication and process coordination will unlikely be realized. Further, peer feedback systems should be designed to request and distribute feedback to each member regularly over the duration of a project. This will allow GVT members to learn from their peers' feedback and adjust their behavior. Although communication and coordination are under control of the GVT members, management must be involved in the development and administration of the feedback system.

Peer feedback may be a viable option for GVTs because it is feasible to implement in typical GVT situations (see Taras et al., 2013). Therefore, in an effort to reduce process losses associated with virtual teamwork, a consistent program of obtaining and disseminating feedback information should be provided. By soliciting feedback from each GVT member and distributing it to respective members, individuals will gain more insight into how they are perceived by his or her peers. This insight can allow individual members to adjust their behavior to more readily meet the expectations of the other GVT members. Stemming from the strengthened relations involving communication frequency, process coordination, and effectiveness, such adjustments will lend to enhanced likelihood that GVTs will successfully complete team tasks and projects.

Strengths, Limitations, and Additional Directions for Future Research

There are two noteworthy strengths of the present study. First, the study context resembles the real-world environments GVTs operate in. In particular, X-Culture GVTs closely resemble realworld GVTs and is a promising platform for studying GVTs, despite the potential for nonprobability sampling (Kline, 2017; see also Taras et al., 2013). This supports the generalizability and external validity of our findings. Although X-Culture comprises a student sample, since GVTs with sufficient comparability do not generally exist in large numbers in organizations, X-Culture provides one means of studying large samples of GVTs. These disadvantages of X-Culture outweigh the limitations of smaller, labbased samples. A second strength is that we used multisource data. In particular, the performance criterion was obtained from course instructor and industry expert ratings, easing concerns over common method bias.

One limitation of this research is that we did not consider self-ratings, which are often also included in peer feedback systems (e.g., Brutus & Donia, 2010). Nor did we consider self- and peer-rating congruence (e.g., Margolis, & Dust, in press). However, considering self-ratings would require additional theorizing that did not fit within this study. In particular, such theorizing would likely have to acknowledge how low self-awareness or rater biases could influence self-other discrepancies (O'Neill, McLarnon, & Carswell, 2015). Nonetheless, a focus on self-ratings would be a valuable line of inquiry that future GVT research should pursue.

Future research could also explore the role of communication quality. Although our measure of communication frequency was aligned with previous studies (see Webster & Wong, 2008), high frequency does not necessarily imply high quality. Highly frequent communication may be a necessary, but not sufficient condition for strong process coordination. For instance, GVTs could communicate frequently, but if the messages are irrelevant to team goals, then frequency might be negatively related to coordination and performance. Thus, future research could consider communication quality as a moderator of the frequency-coordination link. Future research could also consider whether an intervention can enhance communication quality in GVTs. In this

regard, two initiatives that seem promising for increasing communication quality, particularly that which occurs within the peer feedback context, might be calibration training (see Gehringer, 2014) and double loop mutual assessments (see Babik, Iyer, & Ford, 2012).

Conclusion

This study documented relations between peer feedback, communication frequency, process coordination, and performance in a large sample of GVTs. Findings supported the mediating role of process coordination between communication frequency and performance when peer feedback occurs regularly. Giving and receiving regular feedback was associated with a significantly stronger indirect effect as compared to only post-project feedback or when weekly feedback was obtained, but not shared. Thus, the structural support offered by regular peer feedback enhances intra-GVT processes and functioning. Based on this research, organizations looking to optimize GVT performance should consider implementing a peer feedback system that requests and distributes feedback at regular intervals throughout project completion.

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