Learning through time

Learning through time: the role of team reflexivity and virtuality in decision-making teams

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Abstract

Purpose – This paper aims to test if team reflexivity is a countermeasure to the detrimental effect of team virtuality on team performance improvement, in decision-making teams.

Design/methodology/approach – Study 1 regarded 210 individuals (N = 44 teams) executing five decision-making tasks. Study 2 regarded 60 individuals (N = 20 teams) executing four decision-making tasks. Study 1 was longitudinal, with no experimental manipulation. Study 2 had an experimental longitudinal design comprising two between-team manipulations: medium of communication and team reflexivity; the outcome was team performance improvement.

Findings – Study 1's results show that team reflexivity positively moderates the effect of virtuality on team performance improvement over time. Study 2's results shows that a reflexivity manipulation benefits face-to-face teams more so than virtual teams, probably because team reflexivity is more effective when media richness is high.

Originality/value – The implications of reflexivity's lack of effect in low virtuality (Study 1) and high virtuality (Study 2) teams are discussed. This study contributes to the team learning and virtual teams' literatures by expanding current knowledge on how team reflexivity can facilitate team learning under face-to-face versus virtual communication conditions.

Keywords Team reflexivity, Decision making teams, Team learning curves, Team virtuality

Paper type Research paper

Team virtuality regards the degree to which team members rely on technology to share relevant information and make decisions (Kirkman and Mathieu, 2005). Virtual communication hinders team learning during complex decision-making tasks because it limits the sharedness of relevant information and triggers information processing failures (Mesmer-Magnus *et al.*, 2011). This provides virtual teams an information processing disadvantage and may lead to flatter learning curves (lower increases in performance scores over time) compared to face-to-

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face teams (Bell *et al.*, 2012). Yet given the increase in virtual teams, it is crucial that teams learn and improve their performance over time in virtual settings, too.

An effective countermeasure to mitigate the effects of team virtuality on team performance improvement is promoting team learning practices within the organization (Taylor *et al.*, 2021) – "the process of aligning and developing the capacity of a team to create the results its members truly desire" (Senge, 1990, p. 236). One such practice is team reflexivity, i.e. "the extent to which team members collectively reflect upon the team's objectives, strategies and processes, as well as their wider organizations and environments, and adapt them accordingly" (West, 2000). Reflexive teams are more aware of their task environment, share a greater amount of relevant information and are better at exchanging, discussing and integrating knowledge (van Ginkel *et al.*, 2009; Schippers *et al.*, 2014). However, reflexivity does not happen spontaneously in teams. Such limitation can be solved through structured reflexivity practices such as guided reflexivity – an intervention designed to prompt team reflexivity and help team members collaboratively extract meaning from the provided feedback and set new goals and strategies for future performance (Gurtner *et al.*, 2007). Guided reflexivity should be particularly effective to enable high performance in face-to-face (Gabelica *et al.*, 2014) as well as in virtual teams (Konradt *et al.*, 2015). However, research on the relative benefits of guided reflexivity on team performance improvement in face-to-face versus virtual communication conditions is still lacking.

Hence, this research contributes to the team learning and team virtuality literatures by addressing one pressing research question: how can the information elaboration deficits associated with team virtuality be mitigated, and team performance improvement enabled? Such contribution is strengthened with the adoption of a longitudinal design where we unpack the temporal dynamics of team learning outcomes (Edmondson *et al.*, 2007). We regard virtuality as input to team learning outcomes over time (Bell *et al.*, 2012) and consider the moderating role of team reflexivity as a team learning process. We do so by performing one longitudinal simulation study (Study 1), and one longitudinal experimental study (Study 2) with a two-by-two between subjects' design where we examine how different levels (Study 1) and modalities (Study 2) of virtuality predict team performance improvement as team learning curves over time.

Theoretical background

Team learning processes such as reflexivity constitute the "flywheel" of learning organizations (Bui and Baruch, 2010; Senge, 1990). Learning is a core dimension of effective teamwork and happens when team members actively and purposefully engage in sharing ideas and information relevant for the task and the team (Dimas *et al.*, 2015; Rebelo *et al.*, 2020). Team learning is a dynamic process that is entwined with key teamwork outcomes such as innovation, adaptation and performance (Bell *et al.*, 2012). Whereas iterative behaviour in teams can be observed during action regulation or information elaboration activities such as reflexivity, the temporal evolution of team learning is often expressed in terms of change in shared knowledge structures and team performance improvement (Edmondson *et al.*, 2007).

Team performance improvement (i.e. team learning curves) has been the subject of empirical studies that aimed to investigate team efficiency improvements over time during routine tasks, from the beginning of a new performance cycle entailing a specific process (e.g. routine cardiac surgery) or product (e.g. developing a website). Team learning curves should improve with team members' experience, and flatten as new learning subsides (Edmondson *et al.*, 2007).

Research suggests that when team members collectively learn about their roles and their strategy in the beginning of the task, the more positively their learning curves will evolve (Mathieu and Rapp, 2009). This happens because team learning behaviours increase the sharedness and similarity of the knowledge about task procedures and task deadlines (Santos *et al.*, 2015). Whereas it is well-established that the development of team learning curves for co-located teams performing in a stable environment follows a steeper increase near the beginning of an assignment, with the learning curve flattening as learning subsides (Edmondson *et al.*, 2007), it is possible that the progression of such curves is slower during virtual interactions because the richness of the communication process between individuals is lower in virtual interactions, compared to face-to-face interactions (Maynard *et al.*, 2012).

Team virtuality

From a structural point of view, team virtuality is the combination of the use of virtual tools, the informational value they convey and the synchronicity of interactions tools allow (Kirkman and Mathieu, 2005). The extent to which team members use technology tools (e.g. video-calls; texting) to make decisions, share tasks or execute plans is key to identifying teams' dominant communication environment (i.e. face-to-face versus virtual; Kirkman and Mathieu, 2005). The informational value provided by technological tools is important for effective team processes and decision making. The value of information will be as great as the quality, and quantity that a communication channel can carry (Daft and Lengel, 1986). For instance, a videoconference has more information value than an email because a video channel also provides non-verbal cues (although emails allow easier systematization of relevant information). Finally, the synchronicity of team members' virtual interactions (i.e. the extent to which team members' actions are temporally aligned despite physical distance) is also helpful to determine which team informational exchanges occur synchronously, versus those involving asynchronous interactions. Therefore, teams with high virtuality are the ones that use virtual tools to work more often, communicate asynchronously and use communication media with low informational value.

Although team virtuality improves the sharing of unique information (i.e. information that only certain members possess but that would be important for team performance), it also reduces the quality of team behaviours and affects (Peñarroja *et al.*, 2013), triggers team information processing failures and hinders the sharing of general information that enables effective communication and coordination (Mesmer-Magnus *et al.*, 2011). A meta-analysis conducted by Baltes *et al.* (2002) suggests that virtual teams are less effective compared to face-to-face teams when making decisions. As virtual teams vary according to the communication media they use, they will likewise vary in decision-making outcomes. Communication and decision-making are more successful the higher the communications medium is regarding the degree of synchronization and media richness (Baltes *et al.*, 2002). According to these studies, virtual teams perform more poorly on intellective tasks like decision-making tasks. This may happen because although virtual teams generate more creative ideas due to greater social, informational and value diversity (Griffith and Neale, 2001), virtuality also causes additional tension that hinders cognition and decision-making (Maynard *et al.*, 2012).

In work teams, it could be that the more virtuality, the more difficult it becomes to create shared understanding across multiple tasks (Mesmer-Magnus *et al.*, 2011). Hence, team performance improvements should display a less steep trajectory when teams work virtually, rather than face-to-face. Technology-mediated communication allows little physical interaction between team members and gives limited opportunity for agreement on team goals (Griffith and Neale, 2001). Together with ineffective communication, these might

cause breakdowns in team interaction that will negatively affect team performance improvements (Mesmer-Magnus *et al.*, 2011). We expect that:

H1. The slope of team performance improvement is less positive when team virtuality is higher.

Team reflexivity

There is more ambiguity and uncertainty in virtual teams than in teams working face-to-face (Mesmer-Magnus *et al.*, 2011). Hence, the more virtual the environment in which a team works, the more attention to team procedures and structure are needed for success (Maynard *et al.*, 2012). One possible countermeasure to team virtuality is team reflexivity because it helps team members internalize past experiences through reflection, planning and adaptation (West, 2000). Team reflexivity helps team members engage in critical thinking, create task-appropriate representations and make better decisions (Schmutz *et al.*, 2018; van Ginkel *et al.*, 2009). However, disciplined reflexivity does not come naturally or even easily (Gabelica *et al.*, 2014). Reflexive process rather must be planned and organized (Traylor *et al.*, 2021). It could be that for teams who learn how to reflect, the communication inefficiencies associated with virtuality might be fewer because task relevant information becomes explicit if team members learn how to share relevant information.

Hence, the extent to which teams reflect on how they work and perform will buffer the negative relationship between team virtuality and team performance improvement. It could be that the relationship between team reflexivity and team performance improvements over time is stronger for teams performing virtually rather than face-to-face, because reflexivity builds shared knowledge and reduces team information processing failures, both of which are major challenges to good performance in virtual teams (Maynard *et al.*, 2012). We hypothesize that:

H2. Team reflexivity moderates the relationship between team virtuality and team performance improvement; such that team performance improvement due to reflexivity will be greater in virtual teams.

Study 1

Method

Sample. The participants were 210 individuals, organized in 44 teams (M_{size} = 4.57, SD = 0.67). The mean age was 34.37 years old (SD = 10.06), and 65.2% were male. The majority (71.6%) was composed of full-time workers, 18.6% of the teams were students and the remaining 9.5% included both full-time workers and students.

Procedure. Teams were voluntarily participating in a management simulation competition (Global Management Challenge®) and had to manage a fictional company for 5 weeks. Teams made decisions about several strategic and practical management issues (e.g. human resources allocation, product stocking, production rates and so on), and the simulator computes the results of those decisions in terms of investment performance, with the consequent market value and share price changes. After teams submit their responses, and before knowing the results of that week, they received an online survey to complete individually. For the present study, we collected data on virtuality and performance in weeks 1 to 5, and on reflexivity in week 2.

Measures. Team virtuality was measured following Maynard *et al.* (2012), which asks participants to allocate the percentage of time spent communicating with other team

members that week using different means (face-to-face communication, telephone, email, videoconferences, instant messaging, document sharing and other). We have used the average of the sums of the percentages in communication media other than face-to-face as the overall measure of team virtuality over the five weeks.

Team reflexivity was measured by four items (Cronbach's $\alpha = 0.85$) from Savelsbergh *et al.* (2009), on a Likert scale from 1 (*completely disagree*) to 7 (*completely agree*). An example of the items being "We regularly take time to reflect on how we can improve our working methods".

Team performance was collected weekly via the simulator results for each team, in terms of investment performance, an index generated by the simulator, showing how much the company gained from team decisions submitted that week.

Analysis. Hypotheses were tested using Random Coefficient Modelling (RCM; Bliese and Ployhart, 2002), which accounts for non-independence of observations and enables team performance development analysis over time, as well as differences in these trajectories between teams (Bliese and Ployhart, 2002). We estimated growth models using the Nonlinear and Linear Mixed Effects package, with statistical software R (Pinheiro *et al.*, 2013). Before proceeding with data aggregation, we examined the within-group agreement index r_{wg} (James *et al.*, 1984), as well as the intraclass correlation indexes (ICC1 and ICC2), whose values are presented Table 1.

Results

Descriptive statistics and correlations between variables are shown in Table 1.

Results of the baseline model with team performance as the outcome indicated a significant effect for time ($\beta = 469{,}599$, $SE = 78{,}529$, $p < 0.001$) and a marginally significant quadratic effect of time ($\beta = -34{,}476$, $SE = 18{,}826$, $p = 0.069$). Therefore, we included these temporal trends in the analyses. Our analyses revealed no evidence of first order autoregressive autocorrelation for performance (L –ratio= 0.10, $p = 0.744$), whereas a model including a test for heteroscedasticity improved model fit (L –ratio= 73.75, $p = 0.003$). Therefore, we controlled for heteroscedasticity in the remaining models. The final Level 1 model was:

$$Y_{ti} = \pi_{0i} + \pi_{1i}\text{Time}_{ti} + \pi_{2i}\text{Time}^2 + e_{ti}$$

As evident in Table 2, Model 1, we added virtuality by specifying the following level-2 models:

$$\pi_{0i} = \beta_{00} + \beta_{01}\text{Virtuality}_i + r_{0i}$$

	M	SD	rwg(j)	ICC1	ICC2	1	2	3	4	5	6
1. Virtuality	5.05	0.85	0.71	0.59	0.85	1	–	–	–	–	–
2. Reflexivity	46.29	30.81	0.84	0.11	0.16	0.02	1	–	–	–	–
3. Performance t1	6360,10	452,79	–	–	–	−0.16	−0.04	1	–	–	–
4. Performance t2	6792,69	725,92	–	–	–	−0.22	−0.07	0.83**	1	–	–
5. Performance t3	7139.72	910,42	–	–	–	−0.12	−0.09	0.79**	0.93**	1	–
6. Performance t4	7480.30	1.180,11	–	–	–	−0.16	−0.11	0.70**	0.90**	0.95**	1
7. Performance t5	7674.78	1.356,48	–	–	–	−0.20	−0.12	0.67**	0.89**	0.94**	0.97**

Notes: ** $p < .01$. n = 44. The aggregation values for virtuality are the averages of the team virtuality measurements over 5 weeks

Table 1. Means, standard deviations, aggregation indexes and correlations in Study 1

$$\pi_{1i} = \beta_{10} + \beta_{11}\text{Virtuality}_i + r_{1i}$$

Virtuality did not have a significant effect on the intercept (β_{01}= −46,763, *SE* = 66,096, p = 0.483) nor on the slope (β_{11} = −56,603, *SE* = 43,229, p = 0.192), and therefore, provided no support for *H1*.

In Model 2, we added reflexivity as a moderating variable by specifying the following level-2 models:

$$\pi_{0i} = \beta_{00} + \beta_{01}\text{Virtuality}_i + \beta_{02}\text{Reflexivity}_i + \beta_{03}\text{Virtuality*Reflexivity}_i + r_{0i}$$

$$\pi_{1i} = \beta_{10} + \beta_{11}\text{Virtuality}_i + \beta_{12}\text{Reflexivity}_i + \beta_{13}\text{Virtuality*Reflexivity}_i + r_{1i}$$

Reflexivity showed a significant interaction effect with virtuality (β_{03} = 185,165, *SE* = 73,782, p = 0.016) and a significant three-way interaction with virtuality and time (β_{13} = 131,986, *SE* = 45.898, p = 0.005). As shown by comparing graphs A and B in Figure 1, the effect of reflexivity is higher in teams with higher levels of virtuality, providing support for *H2*. In line with previous literature (Maynard *et al.*, 2012; Schippers *et al.*, 2014), the results of Study 1 suggest that team reflexivity is particularly important for team performance improvement in teams that communicate mostly through virtual interactions.

Study 2

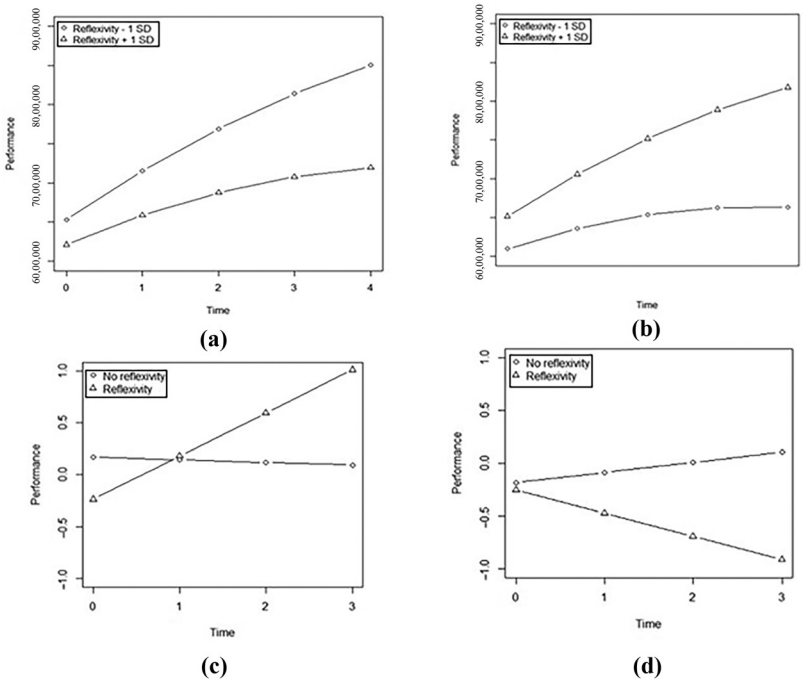
In Study 1, we adopted a commonly used measure of virtuality to warrant the generalizability of our findings and enable theory building (Maynard *et al.*, 2012). However, this measurement approach does not allow us to draw conclusions on which specific dimension of virtuality is responsible for the difference in team performance trajectories. Following Kirkman and Mathieu's (2005) proposal, virtuality is characterized by three dimensions: extent of use of virtual tools, synchronicity and informational value. Study 2 aimed to follow up on the results of Study 1 by focusing specifically on the dimension of media richness, while keeping the use of virtual tools and synchronicity constant. This should allow us to perform a more fine-grained examination of the interplay between reflexivity and the media richness aspect of virtuality and how they contribute to predict team performance improvement (Myers and Ferry, 2001). In addition, with this study we aimed to investigate whether an intervention aimed at fostering reflexivity, would facilitate team performance improvement particularly for teams with low media richness.

Guided reflexivity techniques have been used in a few studies and training programs, with positive implications for work related outcomes such as team performance (Konradt *et al.*, 2015). A highly reflexive team tends to "turn back on itself", helping members

Table 2.
Results of models predicting the temporal trajectory of team performance in Study 1

	Model 1		Model 2	
	Coef.	(SE)	Coef.	(SE)
Intercept	6307.517***	(65.161)	6339.845***	(65.331)
Time	546.885***	(42.640)	492.466***	(44.217)
Quadratic	−54.487***	(13)	−42.530***	(4.313)
Virtuality	−46.763	(66.096)	−33.566	(64.552)
Reflexivity			24.608	(66.917)
Time × Virtuality	−56.603	(43.229)	−47.174	(40.198)
Time × Reflexivity			8.324	(41.605)
Virtuality × Reflexivity			185.165*	(73.782)
Time × Virtuality × Reflexivity			131.986**	(45.898)

Notes: *$p < 0.05$. **$p < 0.01$, ***$p < 0.001$. n = 44



Notes: (a) The effect of reflexivity on performance development in teams with low virtuality (-1 standard Deviation); (b) the effect of reflexivity on performance development in teams with high virtuality (+1 standard Deviation); (c) effect of reflexivity intervention on performance development in teams in the face-to-face condition; (d) effect of reflexivity intervention on performance development in teams in the virtual condition

Figure 1.
Interaction graphs for Study 1 and Study 2

better anticipate the consequences of their actions and, thereby become more productive (West, 2000). Conversely members of non-reflexive teams, lack self-awareness, which can be detrimental to team performance, particularly in dynamic situations (Bell *et al.*, 2012). Previous research suggests that teams who learn how to collectively reflect show greater team performance improvement over time than those who do not learn how to reflect (Gabelica *et al.*, 2014; Schmutz *et al.*, 2018). Moreover, research by Konradt *et al.* (2015) shows that team reflexivity interventions can help in ameliorating team performance for teams communicating virtually. As team reflexivity helps teams being more mindful of their shared knowledge (Santos *et al.*, 2015), and process incoming information more effectively (Schippers *et al.*, 2014), it can be hypothesized that team reflexivity is particularly important for teams whose decision-making must be performed through virtual communication.

H3. A team reflexivity intervention will moderate the relationship between the communication mode and team performance improvement, such that the effect of the reflexivity intervention on team performance improvement will be stronger in the virtual condition.

Method

Sample. Participants included 60 undergraduate and graduate students from a Western European university, randomly assigned to 20 three-person teams. Participants were M = 28 years old (SD = 10.3) and 40% were male. Students received 2.5 credit points for participating in a two-and-a-half-hour session, and the best performing team received a 60-euro bonus.

Research design. The experimental design regarded two between-team factors: media richness (manipulated through audio only vs face-to-face medium of communication) and team reflexivity (manipulated through the implementation vs no implementation of one team reflexivity guided intervention). Performance was measured over four consecutive tasks. Teams were randomly assigned to for conditions with five teams each: virtual - no reflexivity, virtual - reflexivity, face-to-face - no reflexivity and face-to-face - reflexivity. The complex decision-making task was the Maastricht University Emergency Management Simulation - MUEMS (Thommes and Uitdewilligen, 2019). Each team member was randomly assigned to the role of fire brigade commander, police officer or chemical specialist. To simulate expertise, each member received an information sheet unique to their role, explaining their responsibilities and specific algorithms related to their role (e.g. the chemical expert learnt the effects of different chemicals on the development of fires). Then the teams performed four consecutive tasks, which involved making decisions on specific emergency scenarios, including how many and what types of units to send to which locations, which buildings to evacuate, and which roads to close. Within each task, decision outcomes are indicated in terms of costs (e.g. not evacuating individuals who should have been evacuated entails a cost of 100 per individual), so the final solution can be objectively calculated. Successful task completion requires team members to integrate scenario specific information with their own and each other's role specific expertise.

Procedure. Upon arrival at the laboratory, participants were directed to a common room (face-to-face condition) or individual cubiculum (virtual condition), provided informed consent and received role instructions and maps for visualizing the situation. They completed 20-minute-long individual exercises to establish their individual role expertise. Next, teams practised for 25 min on a training scenario with guiding questions that outlined what kind of decisions they were expected to make during the task scenarios. After training, the reflexivity condition teams received a team reflexivity task, and those in the no reflexivity condition received a filler task. Then teams were given a five-minute break. After the break, teams participated in four experimental task scenarios, each lasting maximally 12 min. Teams were instructed to complete a standardized decision sheet and were told that the quality of their decisions would be assessed both by the time they needed and the quality of their decisions. Immediately on completing the decision sheet, they had to notify the experimenter and return it.

Experimental manipulations. Team virtuality was manipulated by creating two distinct conditions. Team members in the control condition worked face-to-face, seated in a single room at three separate desks, positioned so that the team members could easily interact but at the same time could not read one another's information sheets. Team members in the experimental condition were assigned individual cubicles and given microphone headsets to communicate, whereby all three members could communicate simultaneously. These team members could not see each other. Regardless of being in the face-to-face vs virtual communication condition, teams had limitations to the type of information they could convey as speaking was the only form of communication allowed.

In the team reflexivity condition, each team member received a list of questions to discuss as a team for 7 min. The aim of this intervention was to make them reflect on their ways of approaching the task and to develop and implement more effective strategies in the following tasks. Example questions were: "Were procedures created to find a solution? If yes, what were they? Looking back, do you see a more effective way of reaching the

solution?" The participants in the no reflexivity condition received a filler task asking them to discuss what one needed to do to succeed academically at university.

Measures. Team decision-making performance was assessed as the average of the z-scores of decision quality and decision speed. Decision quality was calculated as an objective score based on the relative cost of the team proposed solution. Decision speed was by the seconds remaining when the team handed in their decision sheet.

Analysis

Hypotheses were tested as in Study 1, using RCM (Bliese and Ployhart, 2002).

Results

The correlations between variables are shown in Table 3.

The baseline model with team performance as the outcome indicated no significant main effect of time ($\beta = 0.041$, $SE = 0.07$, $p = 0.559$). Our analyses revealed no evidence of first order autoregressive autocorrelation for performance (L –ratio= 0.18, $p = 0.667$), and a model including a test for heteroscedasticity showed a marginal improvement in model fit (L – ratio= 30.03, $p = 0.069$). Therefore, we controlled for heteroscedasticity in our models when possible. In Model 1, we added the virtuality condition (Table 4).

The model in which we controlled for heteroscedasticity failed to converge, therefore, based on recommendations from Bliese (2016) we reran the mode using the general-purpose optimization routine "optim". However, this did not solve the convergence issue (a problem more common with RCM models, see for instance Lang and Bliese, 2009). Consequently, we ran the model without heteroscedasticity. As in Study 1, the model indicated that virtuality did not have a significant effect on the intercept ($\beta = 0.21$, $SE = 0.15$, $p = 0.156$) nor on the slope ($\beta = -0.01$, $SE = 0.07$, $p = 0.931$), thus suggesting that audio-only team virtuality was unrelated with team

Table 3. Correlations in Study 2

	1	2	3	4	5
1. Virtuality	–	–	–	–	–
2. Reflexivity	0	–	–	–	–
3. Performance t1	−0.45*	−0.06	–	–	–
4. Performance t2	−0.06	−0.25	0.20	–	–
5. Performance t3	−0.43†	0.11	0.19	0.24	–
6. Performance t4	−0.29	0.0	0.10	0.09	0.14

Notes: † < 0.10; * $p < 0.05$. n = 20

Table 4. Results of models predicting the temporal trajectory of team performance in Study 2

	Model 1		Model 2	
	Coef.	(SE)	Coef.	(SE)
Intercept	−0.06	(0.14)	−0.12	(0.10)
Time	0.04	(0.07)	0.07†	(0.04)
Virtuality	−0.21	(0.15)	−0.09	(0.10)
Reflexivity			−0.12	(0.10)
Time × Virtuality	−0.01	(0.07)	−0.13**	(0.04)
Time × Reflexivity			0.03	(0.04)
Virtuality × Reflexivity			0.08	(0.10)
Time × Virtuality × Reflexivity			−0.19***	(0.04)

Notes: †$p < .10$; **$p < 0.01$; ***$p < .001$. n = 20

performance improvement trajectories. In Model 2, we added the reflexivity condition as a moderating variable, which showed a significant interaction effect between the audio-only condition and time ($\beta = -0.13$, $SE = 0.04$, $p = 0.002$) and a significant three-way interaction with the audio-only condition and time ($\beta = -0.19$, $SE = 0.04$, $p < 0.001$). The results suggest that the temporal trajectories of team performance improvement were more positive for teams in the face-to-face condition, and that team reflexivity enhances this relationship. What is more, the results contradict the findings in Study 1 as they show that reflexivity in virtual teams jeopardizes team performance improvement when virtuality consists of audio-only communication (see graphs C and D in Figure 1). These findings reject *H3*.

As previously mentioned, teams in both experimental conditions were communicating with the same degree of synchronicity because no written or delayed media were chosen for teams in the virtual communication condition. Furthermore, the teams in both conditions could not present any graphical or written information to fellow team members. Across experimental conditions, *speaking* was the only way team members could communicate with each other; the difference was only that one group could see each other. As reflexivity has a major verbal component (individuals need to discuss ideas), both groups had the same opportunities verbal-wise. They did diverge, however, in the degree of non-verbal communication potentiality, with teams in the virtual condition not having the possibility to use body language and facial expressions as cues to improve interpersonal communication (Myers and Ferry, 2001).

General discussion

Study 1 was non-experimental, and teams were involved in one management simulation where they had to perform a series of complex decisions over five consecutive weeks. Study 2 followed up on study 1, it was an experimental study involving the manipulation of team virtuality (audioconference vs face-to-face) and team reflexivity (intervention vs no intervention), and teams had to perform a series of complex decisions over four consecutive tasks of 12 min each. The findings of the two studies were mixed. In Study 1, we found that team virtuality had no effect on team performance improvement, does contradicting previous evidence suggesting that virtual teams see their performance decreased due to information processing deficits that steam from structural properties of the virtual environment (Mesmer-Magnus *et al.*, 2011). Nevertheless, we also found that team reflexivity *enabled* the team virtuality–team performance improvement relationship. In line with our hypothesis, the fact that team reflexivity enabled the team virtuality - team performance improvement relationship is explained by the information elaboration and processing benefits of team reflexivity during complex decision-making tasks (Schmutz *et al.*, 2018; van Ginkel *et al.*, 2009).

In Study 2, our goal was to replicate and extent the findings from Study 1. We found that team virtuality was negatively related with team performance improvement, which was in line with our initial hypothesis and previous research (Konradt *et al.*, 2015; Mesmer-Magnus *et al.*, 2011). However, differently from the results we obtained in study 1, we also found that team reflexivity enabled team performance improvement for teams in the face-to-face condition, and dampened team performance improvement for teams in the audioconference (as virtual) condition. We anticipate two main reasons for these mixed findings.

First, the mixed findings could be attributed to the structural characteristics of the virtual environment because virtuality covers the use of technology tools, the information value and the communication synchrony that those tools allow (Kirkman and Mathieu, 2005). Whereas these dimensions were present in Study 1 because of the variety of communication tools that were included in the questionnaire, in Study 2 teams in the virtual communication condition were using an audio tool to collaborate. The audio tool reduced the media richness that exists in face-to-face interactions where verbal and nonverbal information, including gestures and facial expressions, is

processed during reflection and interaction (Konradt *et al.*, 2015). It could be that the teams in Study 2 who received the team guided reflexivity training end up reflecting on task and team related information that was either inaccurate or incomplete. This may have exacerbated the information deficits that naturally occur in virtual settings. It could be that for technological tools with greater information value and synchronicity beyond audioconferencing (e.g. video conferencing; virtual reality), a team reflexivity intervention will enable team performance improvement because sound and image are combined much like face-to-face communication (Bertram *et al.*, 2015; Kirkman and Mathieu, 2005). This combination should enable cognitive group processes like learning, reflexivity, and the construction of shared knowledge structures that depend on verbal and non-verbal cues to elaborate information accurately (van Ginkel *et al.*, 2009).

Conclusion

Through our research we have contributed to the team learning (Bell *et al.*, 2012; van Ginkel *et al.*, 2009; West, 2000) and team virtuality (Mesmer-Magnus *et al.*, 2011; Maynard *et al.*, 2012) literatures by examining under which circumstances of team virtuality and team reflexivity can the information elaboration deficits associated with team virtuality be mitigated, and team performance improvement enabled. We did so by using a multi-study, multi-method approach where the drivers of team learning outcomes were studied (Edmondson *et al.*, 2007). We regarded virtuality as input to team learning outcomes over time (Bell *et al.*, 2012) and considered the moderating role of team reflexivity as a team learning process (West, 2000).

The outcomes of our two studies clarify the specific circumstances under which team reflexivity can either be an enabling or disabling factor of the relationship between team virtuality and team performance improvement. We found that the nature of the relationship between team virtuality and team performance improvement depends on the interaction between the structural features of the virtual environment, and team reflexivity. Virtual teams will benefit from team reflexivity only when the synchronicity and media richness of the available technologies are high, much like in face-to-face collaboration. However, if the virtual environment does not provide informational cues as rich as in face-to-face conditions, team reflexivity is likelier to be detrimental to team performance improvement. Hence, our work addresses previous calls for the clarification of "the extent to which different virtual tools effectively support different group processes" (Mesmer-Magnus *et al.*, 2011, p. 222). Our work also helps extending previous research, thus specifying under which circumstances can team learning behaviours like team reflexivity be an adequate group process to enable team learning outcomes during remote work (Konradt *et al.*, 2015).

Regarding their practical implications, our findings suggest that organizations that want to enable team learning should encourage team reflexivity routines such as team debriefs. This practice can be equally advantageous for face-to-face and virtual meetings, if the technological tools adopted have high media richness (e.g. videoconferencing; virtual reality). Team reflexivity should focus on the internal team tasks and process, the contribution of the team goals to the overall organizational goals, and the interaction and communication processes between different teams within the organization (West, 2000). This implies that team reflexivity may have to supersede team boundaries, thus creating the conditions that will help organizational learning (Senge, 1990; Traylor *et al.*, 2021).

Finally, this manuscript is not without limitations. First, an important limitation of Study 2 is the small sample size, which limits the power of the study and increases the margin of error. As such, we should be careful with generalizing these findings to the general population but interpret them merely as documentation for the existence of the effect. Nevertheless, these results are in line with existing studies that suggest that virtual teams

may benefit less from reflexivity than face-to-face teams (Hertel *et al.*, 2005). Additional research with larger sample sizes is needed to assess the robustness of this effect.

Second, data were not collected in a real work environment, which requires that generalizations of our findings should be made carefully. Third, the low ICC(2) value for the reflexivity variable in Study 1 suggests although individuals' perceptions of the extent to which they engaged in team reflexivity was influenced by their group membership, there was considerable variation in perceptions of team reflexivity within teams. This indicates that in this study, reflexivity cannot be considered as a purely referent shift construct (referring to the common perceptions among the team members about the team level reflexivity) but should to some extent be an additive construct (referring to the average level of the perceptions of reflexivity within the team; Chan, 1998). Yet it has to be noted that the low ICC(2) value made the tests of the team-level relationships somewhat conservative (Bliese, 2000).

Fourth, in Study 1, team reflexivity was regarded as a collective process measured though one questionnaire at the end of the second week of the management simulation (a longitudinal collection was not possible due data collection restrictions), meaning that teams had time to develop teamwork routines such as reflexivity. This should give teams enough time to learn how to reflect virtually. Differently, the reflexivity intervention in Study 2 concerned a one-time short reflexivity intervention that was administered at an early stage of the teams' life cycle. The teams may have lack the time needed to experience the maturation of the ongoing, recursive process of action, reflection, planning and adaptation that characterizes effective team reflexivity (West, 2000). Hence, future extensions of our work could tackle these limitations by testing the effect of a team reflexivity intervention on team performance improvement in real decision-making teams. Such a study could follow these teams from the beginning of a project, delivering the team reflexivity intervention before its onset, and monitor reflexivity, virtuality and performance improvement towards the end. Furthermore, extensions of this research should consider recent conceptualizations of team virtuality highlighting that the structural features of virtuality (e.g. objective distance between team members; type of communication media used) do not completely account for differences between virtual and face-to-face teams (Handke *et al.*, 2020). Teams with the same degree of structural virtuality may *perceive* that their team has *virtual diversity*. This suggests that the extent to which virtuality is detrimental to team performance improvement, as an example, can be moderated by the teams' perception of their own virtuality.

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