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A meta-analysis of the consequences of virtualness on team functioning

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ABSTRACT

Virtual teams in organizations have now become a reality, but there have been only a handful of quantitative reviews on "virtualness" (i.e., teams that are more or less virtual). We decided to conduct a meta-analytic review of the effects of virtualness on team functioning (conflict, communication frequency, knowledge sharing, performance, and satisfaction). To explain inconsistencies in the results of published material on the topic, we also examined the moderating effects of level of analysis (individual/group), method (experiment/survey), and time frame (short/long). Eighty studies were found that covered some part of this domain. Results seem to differ in the relative importance of the factors. Thus though aggregated findings suggested negative effects of virtualness on team functioning, results varied in strength and direction of the moderators, indicating that it was not possible to generalize. For example, the negative effects held only for short-term teams, while in longer-term teams the effects weakened or disappeared.

1. Introduction

The practice of using virtual teams in organizations has become popular. Thus, it is important to organizations and team researchers to understand how "virtualness" affects team performance. We decided to review the empirical research on this topic through a meta-analysis.

Virtual teams have been defined as groups of individuals who work together in different locations on interdependent tasks, sharing the responsibility for outcomes, while relying on technology to provide most of their communication. While early virtual team research usually examined "virtualness" as a dichotomy, either face-to-face or computer-mediated (without physical interaction), virtualness has evolved to include degree of separation of members (distance), proportion of members who work virtually (configuration), and the proportion of time that team members work apart. We adopted Schweitzer and Duxbury's [19] suggestion that "to be considered virtual, a team must have some members who do not work in either the same place and/or at the same time, and therefore, cannot collaborate face-to-face all of the time". Thus, we focused on the *degree of virtualness*, a continuum, ranging from not at all virtual to highly virtual. We only included articles in our study that measured or varied one or more dimensions of virtualness.[3] In doing so, this article differs from others that included articles that do not assess or vary the level of virtualness [16] or that do not analyze the relationship between virtualness and other variables [10].

Narrative reviews of the literature have highlighted inconsistent findings, such as positive and negative [e.g., 7] relations between virtualness and performance. Understanding why such inconsistencies exist could help practitioners. The narrative reviews have also pointed out a predominance of certain types of studies, such as short-term experimental research, and question whether the results are generalizable. In contrast, quantitative reviews, such as meta-analyses, help to address these inconsistency issues and questions.

Meta-analyses quantitatively integrate results reported in existing studies. The analysis increases the power of the conclusions made on the relations between variables. Unlike narrative reviews, meta-analyses adjust for sample size and the reliability of measures, thus providing better estimates of the

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[3] We excluded articles that did not have either a measure of virtualness or a comparison of virtual with face-to-face teams. Neither did we quantitatively review articles at other levels of analysis, such as virtual communities or organizations, as this would confound the results.

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relations between variables. They also allow for the discovery of moderators through the coding of differences between studies. Thus, progress in theory building and cumulative knowledge is achievable with meta-analysis.

The objectives of our meta-analysis were to: (1) examine the extent to which virtual teams research has built cumulative knowledge, (2) quantify the strength of the relationships between virtualness and team processes and outcomes, and (3) explore reasons for contradictory findings.

2. The consequences of virtualness

To examine the effects of virtualness in teamwork, we used the well-known input–process–output (IPO) model that includes *input factors* such as team member characteristics, team- and organizational-level architecture, contextual information, and virtualness; *processes* which are the interactions between team[4] members or communications from individuals involving teamwork, that may be either expressive (interpersonal) or instrumental (task-related); and *outputs* that measure team effectiveness, such as performance on the task or the satisfaction of group members.

The IPO model has been modified as more has been learned about team effectiveness; for example, some mediating mechanisms, initially considered processes, have been identified as emergent states (e.g., cognitive, motivational, or affective states such as potency and cohesion). Therefore, the general term *mediator* is used to describe processes and emergent states. Time has also been recognized to have an important role, which was not captured well in the IPO model. These changes have led to an IMOI (input–mediator–output–input) framework [14]. Within this new framework, it is possible to explain the effects of virtualness on mediators and/or outcomes with the theoretical perspectives of media richness/social presence, attribution theory, and categorization.

Today, groups are more likely to be dispersed, with electronic communication dominating their interaction. Media richness and social presence theories suggest that such communication is less personal, with fewer nonverbal cues. Also, attribution theory suggests that people try to explain their own or others' behaviors by making two types of casual attributions: internal (dispositional) or external (situational). A person's initial attribution of another's behavior is usually dispositional (i.e., the fundamental attribution error) and then corrected, depending on knowledge of the person and/or situation. Virtual teams are likely to make attribution errors because members have less knowledge of their teammates and their environments. Thus there is potential for attribution errors to go uncorrected [6]. Categorization provides a third theoretical perspective: social identity theory, self-categorization theory and the similarity/attraction paradigm all suggest that people categorize themselves into subgroups according to salient cues. Individuals identify more closely with people they perceive as being similar to themselves [5]. In virtual team settings, subgroups may develop. As in- and out-group characteristics become salient in subgroups, individuals become more biased towards their own subgroups [20].

3. Development of research questions and hypotheses

Virtualness is the only input variable we examined. Considering the number of mediator and outcome constructs, the number of possible relationships is quite large. We searched the literature for empirical studies related to virtual teams. Whenever virtualness was included in a study and its relationship to a mediator or outcome variable had been examined in at least one other study, the mediator/output variable was included in our meta-analysis. Therefore, our first general research question was:

> **Question 1:** What are the strengths and directions of the relationships between virtualness and team mediators and outputs?

We also examined the generalizability of the findings. Specifically, by introducing moderating variables, meta-analysis techniques can determine whether between-study differences were partially due to the different conditions in the moderator variables. Research designs and sample characteristics are typical moderators examined in meta-analysis work. Accordingly, three possible moderators that varied most frequently across the primary studies were investigated: the level of analysis (individual versus group), the study method (experiment versus survey), and the time the teams worked together (short versus long-term). Therefore, our second research question referred to moderators:

> **Question 2:** To what extent do level of analysis, study method, and/or time duration moderate the relationships between virtualness and team processes and outputs?

To investigate these questions, we developed specific hypotheses about the effects of virtualness on the selected mediators and outcomes. The choice of processes and outcomes to include in our meta-analysis was driven by three factors. First, we needed typical processes and outcomes to be represented. Second, we were restricted to situations in which multiple empirical studies on the relationship between virtualness and a specific variable existed. Third, we wished to focus on variables where the empirical results were ambiguous, so that our meta-analysis would help to clarify them. Three mediating variables (conflict, communication frequency, knowledge sharing) and two output variables (performance, and satisfaction) met our criteria.

3.1. Main effect hypotheses

Conflict represents perceived discrepancies, incompatible desires, and wishes of the parties involved in a team. Conflict may be divided into three types: relationship conflict (the affective component of conflict that concerns the awareness of incompatibilities in the interpersonal realm); task conflict (differences in opinions about a group task); and process conflict (differences of opinion about the way a task should be performed). Researchers have used conflict measures with labels such as: proportion of disagreement, personal attacks, tension, task conflict, process conflict, relationship conflict, affective conflict and general conflict, or a combination of these. All three types relate to virtual team functioning [9]. For example, it can be argued that moderate task conflict can be beneficial because it results in discussion that can provide a better solution to solve the task. Indeed, Massey et al. [13] found that more productive virtual teams experienced more conflict. However, many studies find that the three types of conflict inter-relate strongly but negatively to team functioning [e.g., 8].

We therefore expected that those in more virtual teams will experience more conflict, while those in less virtual teams enjoy more face-to-face communication, resulting in more informal interaction and socialization. This is likely to result in greater rapport and collaboration, stronger team identity, and lower conflict. Because of distance between team members, conflict is difficult to manage in more virtual teams. Differences in work location can also lead to the formation of in-groups and out-groups within teams. Thus, conflict typically arises between the subgroups due to favoritism of local members.

Although most studies found positive relations (higher conflict for more virtual teams), a few have demonstrated a negative

[4] We use the terms *team* and *group* interchangeably.

relationship [e.g., 21]. Nevertheless, given that the majority of empirical research shows a positive relation between virtualness and conflict, we expected that more virtual teams will experience more conflict:

Hypothesis 1: Virtualness relates positively to conflict.

Our second hypothesis concerns the effect of virtualness on communication frequency (the amount of communication between team members). Without communication, lack of mutual knowledge, misunderstandings (attribution errors), and a lack of contextual knowledge may occur. Unfortunately, communication represents a challenge for virtual teams. Although those in less virtual teams may use the same communication technologies and communicate at the same frequency, patterns of face-to-face communication can differ. Co-location promotes informal communication and therefore more overall communication.

Most empirical research supports this, for example, O'Leary and Cummings [17] found that communication frequency related negatively to virtualness. Thus, we expected that more virtual teams would communicate less and hypothesized:

Hypothesis 2: Virtualness relates negatively to communication frequency.

Knowledge sharing represents another important team process. Researchers have used measures such as amount of information shared, transferred, or exchanged within teams. In traditional teams, the sharing of expertise is an essential group process for team effectiveness. Sharing of information and knowledge is even more critical for cross-functional teamwork and good decision making [18].

Few studies have examined the effect of virtualness on knowledge sharing, and within those, the results have been somewhat mixed, though most reported negative relationships [e.g., 1]. It is, of course, more difficult to share rich information and knowledge through electronic media than face-to-face. Also, geographic dispersion may lower employees' attention to the virtual team task. Geographic diversity can also lead to the creation of sub-groups within a team, where in-groups favor local members and share less knowledge overall. Team identity can also be higher in less virtual groups due to more interaction and social presence. Finally, because virtual teams are often culturally diverse, language skills might limit knowledge sharing. Thus:

Hypothesis 3: Virtualness relates negatively to knowledge sharing.

Outcomes represent the results and by-products that have value to the organization; they may be split in three classes (or dimensions): *performance*, which relates to the team's task and includes team efficiency, productivity, and innovation; *affective reactions*, which include satisfaction and commitment; and *behaviors*, which include indicators of the group's ability to exist over time such as turnover and absenteeism.

We focused on two outcomes: team performance and satisfaction. Performance represents the effectiveness of the outcome with respect to the specific task or project at hand. Researchers have included measures such as project outcomes (e.g., met requirements, within budget, within schedule) and confidence in the decision reached by the group. Because much of the communications in virtual settings take place electronically, causal factors, such as lower social presence and slower communication, might affect performance. Asynchronous and slower-paced communication may lead to less focus and attention to the team activity, resulting in lower performance. In virtual teams, trust takes longer to develop and can be more fragile than in face-to-face teams. Thus, lower trust can negatively influence team performance. Developing mutual knowledge about teammates' environments is also challenging when there is geographic separation, and the lack of this knowledge can lead to attribution errors and undermine team effectiveness.

Nonetheless, virtualness can also provide benefits. For example, creativity of the team may be enhanced by bringing diverse perspectives to bear and encouraging people to share their opinions. Less production blocking takes place in asynchronous communication since people can work at the same time, as well as rehearse their communications. However, most empirical articles suggest a negative relationship between virtualness and performance. Therefore:

Hypothesis 4: Virtualness relates negatively to team performance.

There are several ways in which virtualness could affect team satisfaction. In virtual settings, relationships take longer to develop. Stronger interpersonal relationships and team ties have been linked to motivation and less process loss, which in turn affects team satisfaction. More developed teams communicate more constructively, have more mutual understanding and knowledge (i.e., fewer attribution errors), are able to manage conflict more effectively, and are more cohesive. Therefore virtual teams may have lower satisfaction, at least in the short-term. Cyber-ostracism, where one or more individuals is excluded in group interactions, can also negatively impact team satisfaction in virtual teams. Therefore:

Hypothesis 5: Virtualness relates negatively to team satisfaction.

3.2. Moderating hypotheses

Some of the reported research findings are mixed; for example, Martins et al. [12] note the mixed (positive and negative) relations between virtualness and team functioning. The examination of moderators might help to shed light on these conflicting results. Therefore, we considered how our moderators (level of analysis, study method, and team duration) could alter our five hypotheses.

Results at one level of analysis may not generalize to another and thus mixing levels of analysis may introduce ambiguities into the results [2]. Teams have characteristics that are different from that of individuals who may not agree with the perception of their team-mates. Further, results may be stronger at the team level because constructs usually capture shared beliefs. Therefore:

Hypothesis 6: The level of analysis (group versus individual) moderates the virtualness relationships. More specifically, for groups, rather than for individuals, virtualness relates more positively to (i) conflict and more negatively to (ii) communication frequency, (iii) knowledge sharing, (iv) team performance, and (v) satisfaction.

Most experiments are made on ad hoc, temporary groups, whose members are participating for course credit and are located in one university; in contrast, most surveys are made on longer-term groups of employees from multiple organizations and countries. Because participants in experiments generally have a specific task to complete within a short time frame, all participants (generally students) communicate to the extent necessary, (through whatever media are available) to complete their task. Thus, experimental participants tend to be dedicated to the task and the effects of distance are minimized. This would suggest that weaker relationships for virtualness occur in experiments than in surveys. However, one could also take the opposite view and suggest a converse relationship. Drawing on the tendency of

experiments to be shorter-term (and the logic of H8, presented next), we might expect team processes and outcomes to be less positive for experiments. As we cannot predict the direction of the moderation, we posit:

Hypothesis 7: The study method moderates the virtualness relationships. More specifically, virtualness will relate differently to (i) conflict, (ii) communication frequency, (iii) knowledge sharing, (iv) team performance, and (v) satisfaction for surveys and experiments.

The third moderator was the *amount of time* that teams worked together. This is important because longer-term teams appear to be more likely to exist in actual organizational settings, and team processes and commitment change over time. The negative effects of diversity are likely to be neutralized as members spend more time together [15]. Similarly, communication patterns can change, starting with unidirectional communication but ending with mutual communication. Therefore, as teams develop more fully, differences between face-to-face and distributed teams tend to disappear, and team members become more willing to work to understand the problems of other team members over time [3]. Thus, team duration can change the amount of time that team members want to interact and the perceived benefits of investing in social and working relationships. Therefore:

Hypothesis 8: Team duration moderates the virtualness relationships. More specifically, for shorter term rather than longer term teams, virtualness relates more positively to (i) conflict and more negatively to (ii) communication frequency, (iii) knowledge sharing, (iv) team performance, and (v) satisfaction.

4. Method

By using meta-analysis, the strengths of the relationships between two or more constructs can be assessed by quantitatively combining results from existing (primary) empirical studies to determine the overall relationships. Inconsistent findings are common among primary studies due to measurement error, low statistical power, and different research contexts. Meta-analytic techniques can help overcome some of these problems.

We used several ways to find empirical studies and updated the data with more recent searches. Articles were not restricted to any discipline and were found by searching *databases* (PsycINFO, ProQuest, Web of Science) and *conference proceedings* (Academy of Management (AOM), Americas Conference on Information Systems, Computer Supported Cooperative Work, International Conference on Information Systems), obtaining working papers through personal contacts, searching two Web sites focused on virtual team research (VoNet and virtualteamresearch.org), posting calls for unpublished and 'in press' papers (AISWorld, AOM's Organizational Communication and Information Systems division), reviewing collections of articles on virtual teamwork, conducting a general Google Web search, and examining references in reviewed articles to identify new leads. This resulted in a substantial volume of articles being retrieved; for example, ProQuest covers approximately 1800 business journals from 1971 to the present time. Our search terms were: *virtual, virtualness, distributed, dispersed, global, or remote* combined with *team* or *group*. We excluded studies that contained only qualitative data, examined a relationship that was not used by any other author and/or did not contain all of the data we needed[5]. Although the searches provided us with almost 400 articles that might be included in our meta-analysis, many had to be excluded because they did not match our criteria. For example, for one of our searches (after the removal of qualitative and theoretical articles), 62% did not capture virtualness (either as a measure of virtualness or as a comparison between virtual and face-to-face teams), 30% did not contain the quantitative data needed, 6% did not include enough information for their inclusion, and 2% were articles in which the data had already been published in another article already in our meta-analysis. From all our searches, we found 80 unique and useful datasets from the 79 articles listed in the online Appendix (see http://post.queensu.ca/~ss32/mavt/).

4.1. Coding the data

Meta-analysis can be used to summarize relationships between variables (*effect sizes*) using correlations, mean differences, or proportions. Many meta-analysts summarize correlations because of their prevalence in research articles, which is what we did. For our analysis, one author coded all of the papers based on discussions with the other two authors. Once the coding was complete, we hired a graduate student who was blind to our coding to ensure that the direction of the effects was appropriately coded for each study[6]. Any discrepancies were resolved by the authors.

Most studies captured virtualness as a dichotomous measure (co-located [0] *or* distributed teams [1]). Only sixteen studies examined virtualness as a continuous variable (e.g., combined spatial distance and communication media as a measure). When studies captured virtualness as a dichotomous measure, we transformed the data to point-biserial correlations which were used with the correlations for the continuous measures; this allowed us to examine the overall effects of virtualness.

As with any meta-analysis, we needed to make a series of coding decisions. The first concerned studies in which labels of variables appeared inconsistent with the content of their measures. This was done by comparing the labels in the study with the items used to operationalize them. At least two authors discussed the content of a measure and reconciled any discrepancies with its label. The second concerned moderator levels. For example, regarding team duration, we had to determine the cut-off between short- and long-term teams. Moderator levels are determined by the data available in the empirical studies. Based on this, teams were considered short-term when their members worked together for a day or less and classified as long-term when they worked together for more than a day. Although this time period may seem arbitrary and small, we were constrained by the available data.

Another issue concerned the necessity of aggregating narrow measures into larger measures. For example, some studies reported *process satisfaction* while others reported *outcome satisfaction*; we coded these different aspects of satisfaction into the same outcome variable called "Satisfaction". We did this for three variables: conflict, satisfaction and performance. To check the appropriateness of aggregation, we ran separate analyses on the disaggregated measures and then compared the consistency of the results. For *conflict*, we conducted separate analyses for task, relationship, process, and miscellaneous conflict (such as overall conflict or conflict behaviors); for *performance*, we conducted analyses for measures labeled as performance and measures with other performance labels (such as 'creativity of solution'); and for

[5] Many of the articles did not report all of the data we needed. We contacted authors who provided partial data; some were able to send us the data.

[6] Some of the studies reported mean differences (or some other statistic) on a variable of interest. This mean difference was converted into a correlation, whose sign had to fit the direction of the mean differences reported in the study. The graduate student checked that this sign was appropriate given the mean difference reported in the article.

satisfaction, we conducted analyses for satisfaction with solution, satisfaction with process, and other satisfaction (e.g., general satisfaction). The results showed that the disaggregated measures had the same relationship with virtualness as the overall measure, except for conflict: task conflict was positively related to virtualness, while the other conflict measures were non-significant. Therefore, task conflict is presented separately from the other types of conflict.

We also made coding decisions for studies that presented multiple correlations for the same constructs. Because multiple correlations in a single study create the potential for overweighting studies that contain non-independent data, the results of a meta-analysis may be distorted. To avoid this, we used a conservative approach of choosing one correlation per study to minimize the problems associated with non-independent coefficients. When more than one correlation was reported for the same construct at the same point of time in the same study (multiple dimensions of the same construct), we averaged the correlations into one correlation in order to capture the dimensionality of the construct. When making these decisions, we used the data that most closely represented teams in organizations, making the results potentially closer to practice. For example, when data were reported for multiple points in time, we used the data that most closely represent actual employee teams (e.g., if correlations were presented after 1 month and 3 months for the same variables, we chose the correlation for 3 months). Also, if there was more than one face-to-face condition in the experiment (e.g., both with and without computer support), we chose the condition with computer support, as this most closely resembles actual teams in organizations.

5. Analyses

Meta-analysis provides an estimate of the "true" population effect size for a given relationship via a series of steps. We cumulated correlation coefficients into average effect sizes [4,11].

5.1. Computation of effect sizes

To examine the first five hypotheses, we used simple effect sizes of correlations[7]. A number of studies did not report correlations but we obtained some either by contacting the authors or by converting other reported data (such as *t*-tests, *F*-tests, etc.) to correlations.

We calculated overall mean effect sizes (ρ) by weighting correlations by sample size, correcting both the correlations and weightings for unreliability, performing Fisher's Z-transformations, calculating the overall mean correlations, and then un-transforming the overall mean correlations. These were tested for significance using a z-test and confidence intervals are reported. (In addition, we report the mean effect sizes (r_{xy}) without correcting for unreliability).

5.2. Moderator detection and estimation

Hypotheses H6–H8 were addressed by determining whether the studies included in the meta-analysis came from heterogeneous populations (i.e., whether moderator variables were present or not), and, if so, whether the moderator variables accounted for a significant amount of the residual variance. The Q statistic was used as a test of effect size homogeneity, with a statistically significant Q indicating heterogeneity of effect sizes. For statistically significant Q's, we separated the results by the moderator

[7] In calculating the overall effect sizes for our meta-analysis, we used simple correlations from information presented in the primary articles.

Table 1
Meta-analyses of virtualness with processes and outcomes.

Team Inputs	Conflict (H1)					Communication frequency (H2)				Knowledge sharing (H3)				Performance (H4)				Satisfaction (H5)			
		k^a	n	r_{xy}[b]	ρ^c (CI)[d]	k^a	n	r_{xy}[b]	ρ^c (CI)[d]	k^a	n	r_{xy}[b]	ρ^c (CI)[d]	k^a	n	r_{xy}[b]	ρ^c (CI)[d]	k^a	n	r_{xy}[b]	ρ^c (CI)[d]
Degree of virtualness[e] (overall)	Task	6	630	0.13	0.14*	13	2544	−0.10	−0.11* (−0.15, −0.06)	7	542	−0.21	−0.22* (−0.31, −0.13)	30	3813	−0.09	−0.09* (−0.12, −0.06)	23	2717	−0.07	−0.08* (−0.12, −0.04)
	Other	14	908	−0.06	−0.07																
Degree of virtualness (categorical measure)	Task	5	471	0.28	0.31*	9	840	−0.06	−0.06	3	173	−0.60	−0.61*	23	2483	−0.15	−0.15*	18	1880	−0.15	−0.16*
	Other	12	571	−0.02	−0.02																
Degree of virtualness (continuous measure)	Task	1	159	0.26	−0.33*	4	1704	−0.12	−0.14*	4	369	0.01	0.01	7	1330	0.00	0.00	5	837	0.09	0.11*
	Other	2	337	−0.13	−0.16*																

[a] k = number of studies.
[b] r_{xy} = mean weighted coefficient.
[c] ρ = coefficient corrected for the unreliability of predictor and criterion.
[d] CI: 95% confidence interval.
[e] A higher number represents higher virtualness.
* z-test: correlation is different from 0 ($p < 0.05$).

Table 2
Hypothesized moderators.

Relationships	Q	Level of analysis (H6)	ρ^a (k^b,n)	Method (H7)	ρ^a (k^b,n)	Team duration (H8)	ρ^a (k^b,n)
Virtualness – Task conflict	77*	Individual[c]	0.05 (2,433)	Experiment[c]	0.33* (3,404)	Short[c]	0.37* (2,355)
		Group[c]	0.33* (4,197)	Survey[c]	−0.20* (2,226)	Long[c]	−0.18* (4,275)
Virtualness – Other conflict	59*	Individual[c]	−0.21* (3,420)	Experiment	−0.05 (10,504)	Short[c]	0.03 (8,372)
		Group[c]	0.05 (11,488)	Survey	−0.09* (4,404)	Long[c]	−0.16* (5,358)
Virtualness – Communication frequency	252*	Individual[c]	−0.04 (9,2239)	Experiment[c]	0.01 (7,600)	Short[b]	0.05 (6,517)
		Group[c]	−0.30* (4,305)	Survey[c]	−0.11* (6,1944)	Long[c]	−0.18* (6,758)
Virtualness – Knowledge sharing	67*	Individual[c]	−0.15* (3,318)	Experiment[c]	−0.61* (3,173)	Short[c]	−0.67* (1,59)
		Group[c]	−0.34* (4,224)	Survey[c]	0.01 (3,353)	Long[c]	−0.10* (5,417)
Virtualness –Performance	276*	Individual[c]	−0.04 (9,2220)	Experiment[c]	−0.17* (12,889)	Short[c]	−0.27* (11, 750)
		Group[c]	−0.19* (21,1593)	Survey[c]	−0.08* (16,2924)	Long[c]	−0.07 (16,1919)
Virtualness –Satisfaction	262*	Individual[c]	−0.11* (14,1990)	Experiment[c]	−0.03* (16,1525)	Short[c]	−0.22* (12,1178)
		Group[c]	0.00 (9,727)	Survey[c]	0.12* (7,1192)	Long[c]	0.05 (10,1361)

[a] ρ = coefficient corrected for the unreliability of predictor and criterion.
[b] k = number of studies.
[c] Test of the differences between correlations (across the two levels of the moderator) was significant.
* $p < 0.05$.

variables (individuals/groups, experiments/surveys, and short/long-term) to determine if the correlations differed across these moderators.

6. Results

All of our main and homogeneity effects were significant, and therefore post hoc power analyses were not needed. Nevertheless, we calculated power and found that it was >0.90 for all relationships except for knowledge sharing (power = 0.59). Table 1 presents the meta-analytic results for the relations between virtualness and team processes and outcomes (H1–H5).

We first examined the results for the overall (combined) measure of virtualness. Hypothesis 1 was supported for task conflict ($\rho = 0.14^*$), but the results were not significant for other types of conflict. The findings were consistent with the rest of the hypotheses: Hypotheses 2 ($\rho = -0.11^*$), 3 ($\rho = -0.22^*$), 4 ($\rho = -0.09^*$), and 5 ($\rho = -0.08^*$) were supported.

Turning to the two measures of virtualness presented in Table 1, four of the five hypothesized relationships differ significantly. For each of these, the relationships were more likely to be in the hypothesized direction for the categorical than for the continuous virtualness measure (see Table 1).

6.1. Moderators

When observing the relationships within the individual studies, we saw differences between studies, suggesting the presence of moderators. For team performance, we found 30 studies that empirically examined the relationship with virtualness: six with medium to relatively strong positive effects (defined as a rho of 0.20 or larger), seven with medium to relatively strong negative effects, and 17 with a mix of weak (positive or negative) effects. Studies also showed conflicting results for the effects of virtualness on communication frequency, conflict, knowledge sharing, and satisfaction.

The possibility of moderators (H6–H8) was examined via the Q statistic. As all had a significant Q ($p < 0.05$), we further analyzed these relationships by splitting the data on the three moderators of individual/group, experiment/survey, and short-term/long-term (see Table 2). All comparisons for level of analysis (group versus individual) as a moderator (H6) were significant. However, the relationship for satisfaction was in the opposite direction than proposed (with individual level of analysis being stronger). All comparisons for study method (survey versus experiment) as a moderator (H7) were supported, except for other conflict (with no significant difference found). All comparisons for team duration (short- versus long-term) were supported, except that communication frequency was in the opposite direction than that proposed (with long-term being more negative).

7. Discussion and implications

Our first goal for this meta-analysis was to examine the extent to which research presents a cumulative body of knowledge regarding how virtualness affects team functioning. We found this to be lacking. Drawing on the traditional IPO model, the theoretical perspectives of media richness/social presence, attribution theory, and categorization helped to explain our hypotheses. The overall results, summarized using 80 data sets (representing responses from over several thousand participants), supported our main hypotheses: more virtual teams exhibit higher task conflict and lower communication frequency, knowledge sharing, performance, and satisfaction. Although these findings are consistent with more recent research, our results suggest that the results do not generalize to all types of teams and methodological approaches.

Our choice of moderators was dependent on the empirical articles available, and we were able to examine only one theoretically-based moderator, time. We found that higher virtualness in short-term teams (a day or less in our analysis) did negatively affect the team (e.g., more conflict, less communication and knowledge sharing, weaker performance and lower satisfaction). However, in longer-term teams, virtualness did not have nearly the same detrimental effects. There was no negative effect on team performance and satisfaction, and team conflict was reduced as virtualness increased. While still having a negative effect on communication frequency and knowledge sharing, the effect was considerably weaker than in short-term teams. It is important to note, however, that most of the studies investigating short-term teams (a day or less) involved students, whereas studies focusing on longer-term teams (more than a day) involved students as well as employees.

Virtualness clearly has a different effect on teams depending on the length of time the team works together. For short-term teams, leaner media, misattributions, and subgroups all potentially contribute to less effective teams. For example, media richness theory would suggest that the slower ability to communicate rich

information and interact back and forth via electronic media would have a much larger impact on team effectiveness for short-term teams than for teams with several days or weeks to accomplish their tasks. (However students in large courses may also have many people in their groups who know and have worked with one another). For longer term teams, members would also be less likely to make misattributions to the person: as team members interact, they build knowledge about each other and develop relationships. Also, as knowledge of the underlying context and the parties involved in the communications grows, the ability for understanding and the richness of the messages also grow. Similarly, as people start to identify with a team and build a team identity and psychological and affective ties to the team, this helps to overcome other sources of differences.

In terms of methods variables, we found differing results based on several comparisons. First, results are more encouraging for studies using continuous rather than categorical measures of virtualness. That is, for studies with continuous measures of virtualness, the relationship with task conflict is more negative (lower conflict for more virtual teams), the relationships with knowledge sharing and satisfaction are more positive, and there is no impact on performance. Measuring virtualness as a categorical variable might be a simplistic view that does not capture the reality of virtual work in a natural setting. It might be portraying a "spurious" view of the effects of virtualness on processes and outcomes in the real world. Studies using a categorical measure are more likely to be experiments with students and experiments are designed using stronger manipulations, resulting in bigger effect sizes. Because studies using continuous measures are more likely to investigate longer-term employee teams using a survey methodology, we might be able to be more optimistic concerning virtual team functioning in organizations. Furthermore, past research on virtual teams has often confounded technology use with measures of virtualness. That is, they compared distributed groups using one tool (such as e-mail) with co-located groups with no tools. Further, for the articles that provided bundles of technologies to team members, there was no single set of technologies provided across the articles and therefore we could not determine the effects of particular technologies for virtual teams.

We found that another methods variable, the level of analysis (group versus individual) also moderated the virtualness relationships. As expected, there were stronger effects of virtualness on task conflict, communication frequency, knowledge sharing, and performance at the group level than at the individual level. However, the effects of virtualness on other conflict and satisfaction were stronger at the individual level than at the group level.

7.1. Implications for research and practice

Researchers should be very specific about the nature of the teams they are studying (e.g., define how long they have existed) and use theoretical arguments and empirical findings that appropriately match the types of teams. Our results provide valuable advice for designers and leaders of virtual teams. For practitioners, our results suggested that virtual team processes would be more negative in the short-term. Organizations will need to expect these difficulties and put into place structures to help minimize their impacts. Recognizing that virtual teams will have communication and conflict challenges (which influence team functioning), we need to help identify ways to improve effectiveness. For example, team members should be trained to handle conflict to minimize its negative impact on productivity. For long-term teams, practitioners should expect initial challenges, but they could move more rapidly to less negative stages.

7.2. Limitations

As with any research, this meta-analysis has limitations that must be considered when interpreting the results. Meta-analytical work is only as meaningful as the primary studies from which it is derived. We found a lack of consistency concerning measures and reporting standards. Because of the large variety of measures used, we sometimes had to collapse narrow measures into larger categories, reducing the variance in some measures. A further weakness in the literature is the small number of studies examining some relationships. Although we searched for unpublished papers, this study is still subject to the so-called "file drawer" problem, or the difficulty of finding non-significant results since they tend to stay unpublished. We also found articles that did not report needed information such as the level of analysis. More disturbing was the lack of reported data needed to conduct the analyses (effect sizes, sample sizes, etc.): we had to exclude many papers because of a lack of necessary data (whose authors could not provide it).

It is also important to note that moderators often can relate to each other (e.g., in our reviewed studies, we found that study method [experiment/survey] correlated 0.68 with time duration [short/long]). Few studies try to separate their independent effects. Although we examined these effects with our moderator analyses, it is not clear whether results for studies using continuous virtual measures are more encouraging, because the method tends to be non-experimental and these teams have access to a wider range of communication tools, and because teams are made up of employees, or are longer-term.

8. Conclusion

Our meta-analytic review demonstrated that not all virtualness measures are the same and that some conflicting results are due to this and other moderator variables (such as study method). As a result, this study highlights and helps explain conflicting results, and points to empirical gaps in our knowledge and the necessity to inform practice by building a cumulative body of research in which variables are systematically investigated.

The results of our meta-analysis suggest that team processes and outputs are negatively influenced by virtualness. However, these results do not generalize to all types of teams and analytical approaches. The moderation analysis indicates that virtualness has a different influence on team functioning depending on how it is measured as well as on the length of time the team works together. The negative effects found in short-term teams weaken or disappear in teams that have longer lives. Our results also point to important differences on the effects of virtualness for different levels of analysis (individual vs. group) and methods (experiments vs. surveys). We need to know more about how different levels of analysis interact with each other, as well as utilize finer and multidimensional measures of virtualness. All of this can help us understand how to improve team processes and outcomes to more fully take advantage of the potential benefits of virtual work.

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