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The medium isn't the message: Introducing a measure of adaptive virtual communication

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Abstract: Media use can be considered as an integral part of virtual communication and thus of present-day human interaction. Nevertheless, research on media use and effects still largely relies on laboratory experiments, treating it as a stable input condition, rather than as a function of human appropriation. In this study, we propose a conceptualization of virtual communication as a dynamic construct dependent on media appropriation, particularly of compensatory adaptation processes. Using longitudinal data gathered from 165 individuals, nested in 34 project teams, we explore compensatory adaptation as a function of communication intensity and physical media richness and develop a continuous score of virtual communication accounting for these compensatory processes. Multilevel analyses demonstrate a significant influence of this communication measure on team performance, increasing over time. These results are discussed with regards to their implications for theories of media use and effects and their relevance for real-life communication processes.

Subjects: Communication Technology; Interpersonal Communication; Communication Research Methods; Communication Theory

Keywords: communication research methods; media; analysis of variance

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Lisa Handke and Eva-Maria Schulte are research associates at the Department of Industrial/Organizational and Social Psychology at the TU Braunschweig (Germany). While Lisa's research interests include communication and virtuality in teams, using both behavioral and survey data, Eva's research focusses on teams, leadership, well-being, and coaching. The current article relates to an interdisciplinary project funded by the German Research Foundation, analyzing communication in software engineering teams. The project is led by Kurt Schneider (Department of Software Engineering, Leibniz Universität Hannover), who conducts research on requirements engineering and determinants of software project success and Simone Kauffeld (Department of Industrial/Organizational and Social Psychology, TU Braunschweig), who focusses on various aspects concerning competencies, team interaction, consulting, and leadership.

PUBLIC INTEREST STATEMENT

E-mail, chat, and telephone are only some examples illustrating that our communication regularly occurs on a virtual basis—regardless of whether our colleagues work on the same floor or on another continent. However, virtual communication has also been blamed for performance breakdowns by causing problems such as coordination difficulties, misunderstandings, and psychological distance. This article sheds a different light on individuals' virtual communication by adopting a more user-centered approach. Accordingly, we look not only at how individuals adapt their virtual communication to their communication partner but also how this changes over time. Moreover, we propose that individuals compensate for leaner media (e.g., e-mail) by increasing their communication intensity. The results of our longitudinal study not only show that compensation occurs but that it can be linked to team performance. Thus, by compensatory behavior, individuals can achieve both work flexibility and effective communication at the same time.

The prevalence of virtual teams has increased dramatically over the past decade (Gilson, Maynard, Jones Young, Vartiainen, & Hakonen, 2015; Schmidt, 2014). This can be explained by many benefits, such as time- and cost-savings as well as increased flexibility—for organizations as well as their employees (e.g., Hertel, Geister, & Konradt, 2005; Kanawattanachai & Yoo, 2002). However, past research has shown that especially on the short term, virtual teams are susceptible to performance losses (de Guinea, Webster, & Staples, 2012; Nguyen-Duc, Cruzes, & Conradi, 2015). These performance-impairing problems are often attributed to difficulties in intra-team communication and coordination. With the absence of situational information on their team members' work settings and lack of social-emotional cues in their communication, virtual team members are prone to feeling psychologically distant from one another (Cramton & Orvis, 2003; de Guinea et al., 2012). Together with the increased chance of misunderstandings, this strongly impedes team members' ability to anticipate each other's actions and thus to coordinate their behavior with one another.

Traditionally, these findings are explained by the lack of bandwidth (i.e., the number of communication cues a medium can transport) of virtual media (e.g., Daft & Lengel, 1986; Short, Williams, & Christie, 1976). In this context, one often encounters “rational choice models” (Fulk, Schmitz, & Steinfield, 1990), such as media richness theory (MRT; Daft & Lengel, 1986). These models are based on the notion of a rational and efficiency-motivated choice of medium (which remains fairly static in its characteristics) with regards to the respective requirements of the team's tasks. Performance impediments are thus explained with a misalignment of these two factors. Apart from a range of inconsistent or even contradictory findings challenging these traditional models (e.g., Dennis & Kinney; El-Shinnawy & Markus, 1997), their implications for real-life teams seem restricted. In reality, neither can media choices always be made on the basis of optimal efficiency nor do individuals make these choices independently of their social context (Fulk et al., 1990; Walther & Parks, 2002). Moreover, many studies confirming the tenets of rational choice models rely on results obtained in experiments (e.g., Andres, 2002; Kahai & Cooper, 2003), strongly restricting their generalizability to real-life teams, which work together for a longer period of time and usually have more flexibility concerning the way they structure their work, such as choosing the media they communicate with (e.g., Hackman, 2002; Richardson, 2010).

These aspects are addressed in theories allowing for both social, as well as individual and temporal influences (e.g., social influence model of technology use, Fulk et al., 1990; adaptive structuration theory, Desanctis & Poole, 1994; channel expansion theory (CET), Carlson & Zmud, 1999; compensatory adaptation theory (CAT), Kock, 1998; 2001). Here, individuals do not have to be restricted by the media's physical properties, but can actively shape media characteristics through their own perceptions, attitudes, and appropriation. They are capable of adapting media to their causes by compensating suppressed communicative cues and can enhance their own richness perceptions through experience.

While the notion of channel expansion and compensatory adaptation has been broached theoretically by many scholars (Barry & Fulmer, 2004; Carlson & Zmud, 1999; Kock, 1998, 2001), empirical evidence is still rare (Hantula, Kock, D'Arcy, & DeRosa, 2011). Even here, most studies are based on experimental laboratory designs, treating virtual communication as a categorical concept, thus failing to acknowledge the continuous nature it has in reality (de Guinea et al., 2012). Many scholars agree on the fact that all teams in modern organizations can be considered as more less virtual to some extent (Bell & Kozlowski, 2002; Kauffeld, Handke, & Straube, 2016; Kirkman, Gibson, & Kim, 2012). This complements recent findings indicating an alleviation or even disappearance of negative effects of virtuality, when operationalized as a continuous measure (de Guinea et al., 2012). Accordingly, we see a dire need to not only to operationalize virtual

communication in form of a continuous measure but to analyze more modern concepts such as compensatory adaptation in a longitudinal field context.

Beginning with a review of media choice and effects models that have not only strongly influenced prior studies in this field but which we consider pivotal to the derivation of our hypotheses, our study pursues the following purposes: First, we want to conceptually establish compensatory adaptation as an interaction between physical media richness (i.e., media use weighed by its properties, rather than its—partly socially constructed, cf. Dennis, Fuller, & Valacich, 2008—characteristics) and communication intensity. Second, as a premise for compensatory adaptation to take place, we intend to demonstrate intra- and interindividual variations in communication. Third, we seek to find proof of the existence of compensatory adaptation in the terms we defined. Finally, we aim to develop and demonstrate the validity of a continuous score of communication that allows for compensatory adaptation processes, constituted by physical media richness and communication intensity. Our study will be based on analyses of longitudinal survey data, gathered via weekly self-reports of media use, communication intensity, and team performance.

1. Communication and virtuality

Communication is a team process fundamental to performance (e.g., LePine, Piccolo, Jackson, Mathieu, & Saul, 2008; Mathieu, Maynard, Rapp, & Gilson, 2008). Due to rapid technological advancements and benefits such as increased flexibility, mobility, and cost-savings, it also occurs using a variety of media other than face-to-face (FtF) interaction (e.g., Gilson et al., 2015; Kauffeld et al., 2016). Accordingly, the body of research on virtuality (or virtualness, virtual teams, etc.) has also grown rapidly (see Gilson et al., 2015 for a review). In the context of this paper, we will employ the term virtuality, but will draw on studies synonymously using other terms, e.g., virtualness or virtual teams. Common to the majority of virtuality definitions is technology use and/or media richness (e.g., Ganesh & Gupta, 2010; Hoch & Kozlowski, 2014; Kirkman & Mathieu, 2005). As most teams vary in the extent to which they interact via virtual media versus FtF (e.g., Bell & Kozlowski, 2002; Kirkman & Mathieu, 2005), this not only implies that the concept of virtuality applies more or less to most organizational teams (e.g., Gilson et al., 2015; Kirkman et al., 2012) but that implications drawn from virtual team research may render important insights for all teams situated somewhere along the virtuality continuum. Moreover, the role of technology use also explains why such a large proportion of research on virtuality and its effects draws on studies (mostly laboratory experiments) contrasting computer-mediated communication (CMC) with FtF interaction (see de Guinea et al., 2012, for a meta-analysis). Accordingly, the following sections devoted to the theoretical background of our study will largely focus on CMC.

2. Communication and media richness

When trying to uncover the (particularly negative) effects of CMC, one usually comes across either social presence theory (SPT; Short et al., 1976) or Media Richness Theory (MRT; Daft & Lengel, 1986). Both these theories address the lack of nonverbal cues in CMC in order to account for media effects (e.g., Fulk et al., 1990; Walther, 1992; Walther & Parks, 2002).

As alluded to in its name, SPT draws on the concept of social presence. Social presence refers to the extent to which a medium facilitates awareness, i.e., salience, of the other person. Short et al. (1976) argue that the greater the bandwidth, i.e., the number of communication cues a medium can convey, the greater the social presence of the communicators. Accordingly, FtF interaction, which is rich in (particularly nonverbal) cues may be regarded as having the greatest social presence, followed by a combination of audio and video (e.g., videoconferencing), audio-only and, lastly, text-only. According to SPT, the lower the degree of social presence, the more impersonal the message it transports—thus accounting for the generally higher degree of task-orientation in CMC (cf. Walther, 1992). Effectiveness of a medium is considered to depend on whether its level of social presence “matches the level of interpersonal involvement required for the task” (Fulk

et al., 1990, p. 118). Hence, media low in social presence, such as e-mails, are effective particularly for tasks involving simple information exchange.

The notion of a fit between specific tasks and physical media properties can also be found in MRT. Paralleling the concept of bandwidth and social presence found in SPT, MRT assumes that media vary with regards to their capacity for immediate feedback, utilization of multiple cues and channels, degree of personalization, and language variety. These capacities, in turn, influence the richness of the information transported by the medium. An example for a rich medium would thus be FtF interaction, as it provides immediate feedback, enables the use not only of verbal but also of para- and nonverbal cues such as voice and body language, is highly personal, and uses natural language. Whereas rich media serve to reduce equivocality (i.e., ambiguity about how to interpret information), leaner media (e.g., e-mail), which only offer a limited number of cues and feedback possibilities, are a fine match for unequivocal messages. Consequently, MRT argues that task performance depends on the fit between the information needs of the task at hand and the medium's information richness (later just referred to as media richness).

More recent theories that extend MRT to encompass “newer” media, such as CMC, are the task-media fit hypothesis (McGrath & Hollingshead, 1993) and media synchronicity theory (Dennis et al., 2008; Dennis & Valacich, 1999). All of these theories convey a specific message: Certain media (properties) are more suited for certain tasks than others, thus leading to rationally better or worse media choices (ergo the term “rational choice models”, Fulk et al., 1990). This fairly simple and common-sense proposition has been widely used as an explanation for specific media choices as well as for negative effects of CMC (for a review, see Walther & Parks, 2002).

3. Boundaries of rational choice models

While there have been a few early empirical studies in support of these theories (Rice, 1992; Trevino, Lengel, & Daft, 1987; Webster & Trevino, 1995), even more appear to have yielded either no/inconsistent (e.g., El-Shinnawy & Markus, 1997; Suh, 1999), or even contradictory results (e.g., Dennis & Kinney, 1998; Markus, 1994).

The problem with these *rational choice models*, as Fulk et al. (1990) describe them, is their assumption that all media have fixed, inherent properties (i.e., information richness) and that individuals make independent choices (i.e., as if their interpersonal setting had no influence)—the process of which is purely cognitive (behavior follows cognitive evaluation of media attributes and requirements), objectively rational (the optimal combination of the assessed task requirements and media properties), and efficiency-motivated (media capacity is a resource which shall not be “wasted”).

These assumptions are challenged by studies uncovering social influence processes as well as seemingly irrational or at least not efficiency-motivated media choice and use. They consistently show situations where rational choice models would suggest FtF communication to be the most appropriate choice and yet individuals working on collaborative tasks opted for CMC instead (e.g., Markus, 1994; Ngwenyama & Lee, 1997). Further studies reveal CMC to be high in relational exchanges (e.g., Walther, 1992; e.g., 1994)—thus opposing SPT's assertion that CMC leads to impersonal communication. Yet other investigations yielded CMC outcomes equal (or even superior) to FtF communication (e.g., DeRosa, Smith, & Hantula, 2007; Kock, 1998; Simon, 2006).

Yet how can we explain the paradox between these findings and those complying with the tenets of rational choice models? To do so, we suggest looking at the methodology behind these investigations. Most studies showing CMC to be inferior to FtF communication employed experimental settings, thus constituting “one-shot” situations, i.e., concentrating solely on short-term use and effects, based on interactions of ad hoc groups or dyads (e.g., Bordia, Difonzo, & Chang, 1999; Bos, Olson, Gergle, Olson, & Wright, 2002). In turn, studies employing experiments where participants anticipate future interactions (Walther, 1994; Walther & Burgoon, 1992), were not

subjected to time limits (Walther, Anderson, & Park, 1994), or field studies (e.g., Kock, 1998, 2005) have yielded very different results.

These insights suggest the following: The nature and effectiveness of media choice is likely to develop as a function of social influence, temporal dynamics, and the individuals using the medium. We will elaborate upon this reasoning in the following sections.

4. Social influence

The fact that human behavior occurs in a social context is the fundamental tenet of social psychology, and under this assumption, it seems highly unlikely that virtual communication does not underlie social influence processes. The social influence model of technology use (Fulk et al., 1990) assumes that media evaluations (perceptions and attitudes) are simultaneously influenced by objective media features, experiences, as well as social influences (e.g., social norms or direct statements by others in reference to a medium). Being inherently social creatures, individuals are motivated to gain psychological-level knowledge of one another and develop relationships (Walther, 1996). Challenging SPT's notion of the impersonal nature of CMC, Walther's model of social information processing (SIP; Walther, 1992, 1996) asserts that individuals will be able to show a high degree of relational communication in CMC, given sufficient time and message exchange. In their urge to develop relationships, individuals will test their assumptions about one another (i.e., their initial impressions) over time in order to gain psychological-level knowledge. Lacking the nonverbal cues found in FtF interaction, individuals form their impressions via alternative cues—they exchange social information through elements such as content and style (Utz, 2000), or even timing (Walther & Tidwell, 1995).

5. Time

Time is a critical variable in CMC—information exchange is slower, words take longer to write than to speak, and fluency is impaired (Kock, 1998, 2007). Moreover, due to the often asynchronous nature of CMC, individuals are able to control their self-presentation, i.e., via additional reflection and editing, because they have more time to do so (Walther, 1992, 1996). Time is also an essential element of CET (Carlson & Zmud, 1999). CET assumes that knowledge-building experiences with the channel (i.e., the medium), communication partner, topic and context enhance the perceived channel richness. By gaining experience with a channel, individuals increase their knowledge base on how to skillfully apply this channel in a variety of situations. Moreover, they will likely also become more adept at interpreting messages more richly (having experienced a variety of different cues) sent via this channel. Both of these aspects account for an increasing perception of richness as a function of experience. Similarly, the psychological-level knowledge (cf. Walther, 1992) individuals gain about one another with experience may help de- and encode messages suited to the particular communicator. Experience with a certain—or similar—topic means a better use and understanding of task-specific terminology, enhancing the interpretation of messages with regards to the topic and thus the perceived richness of communication. Finally, in gaining experience within a particular context, individuals will become better at encoding messages with richer meanings for communication partners sharing their context, e.g., by using symbols or references common to the context and thus shared by its members.

6. Media appropriation

As previously alluded to in the context of SIP (Walther, 1992, 1996) and CET (Carlson & Zmud, 1999), individuals learn to de- and encode messages sent via physically leaner media, thus changing their subjective richness. This notion is further elaborated in Kock's (e.g., 1998, 2001, 2005) Compensatory Adaptation Theory (CAT), which argues that “individuals using media that suppress many of the elements of face-to-face communication (e.g., e-mail) do not accept passively the obstacles posed by the use of those unnatural media” (Hantula et al., 2011, p. 347). According to the compensatory adaptation principle, individuals will (voluntarily and involuntarily) compensate for these obstacles by altering their communication behavior, due to improved en- and decoding of messages conveyed via the leaner medium. For example, individuals

will exert more care and effort into preparing messages they sent via leaner media to make up for the absence of specific cues. This corresponds to findings by Kock (1998) who found a higher contribution length via CMC over time as well as to those found by Fuller and Dennis (2009), showing changes in media appropriation in form of longer messages. In fact, even Short et al. (1976) acknowledged the higher presence of verbal expressions of agreement and disagreement in telephone communication, which they presumed to constitute a compensation for the lack of nonverbal cues of (dis)agreement. Decoding, in turn, refers to the interpretation of messages, i.e., filling in the blanks that may be caused due to a lack of certain cues in order to perceive the message as richer (cf. Carlson & Zmud, 1999).

This compensatory effort, particularly with regards to encoding, is supported by findings showing a lower communication fluency and higher perceived effort in CMC over FtF communication (e.g., Kock, 2005, 2007). Nevertheless, studies were also able to show that this additional effort did not necessarily coincide with lower performance in CMC compared to FtF communication (Kock, 1998, 2005). Once again, time is of the essence—the more time passes, the more skills individuals acquire to de- and encode messages sent via leaner media (cf. Carlson & Zmud, 1999) and the more natural the medium will seem to them (DeRosa, Hantula, Kock, & D'Arcy, 2004). Moreover, the increased cognitive effort imposed on individuals compensating for unnatural media may partly be alleviated as group members reach a shared understanding on how to coordinate their actions and can resort to more implicit and, in turn, less effortful communication processes (cf. Langan-Fox, Code, & Langfield-Smith, 2000).

7. Measuring communication as a dynamic construct

Based on the aforementioned theories and their assumptions, we arrive at the following conclusion: virtual communication is a dynamic construct—contingent on factors such as time and experience, social influence, and appropriation. Why, however, is it so often being treated as static? This refers not only to the fact that we often ignore changes in task, context, and group compositional factors over time. We also need to acknowledge that individuals react to these changes with behavioral and perceptual alterations of their own. Individuals obviously manage to compensate media restrictions, alter their perceptions of richness and show variations in both over time. Media use is a construct that cannot be based on physical media properties, but that should be regarded as a higher-order construct based on appropriation, which in turn is a process underlying both social and individual influences.

While these processes are more or less acknowledged in CAT, its empirical underpinning may yet be increased (Hantula et al., 2011). Albeit the range of experiments aiming to prove its validity (e.g., Kock, 2005, 2007; Simon, 2006), given the mixed results provided by experimental designs, we urge for a stronger focus on field studies, particularly longitudinal ones (Hantula et al., 2011). To our knowledge, most of the field studies leaning on media compensation are strongly descriptive, based on very small samples, with five or less teams (DeLuca, Gasson, & Kock, 2006; Kock, 1998; Maznewski & Chudoba, 2000). Our first aim is thus to analyze the occurrence and effects of media compensation in the context of a longitudinal field study.

Furthermore, as most findings on media use and effects (and thus implications for virtual teams) are based on experimental laboratory designs, the general concept of virtual communication is often treated as categorical—mostly as dichotomous (i.e., FtF vs. virtual). This fails to reflect the reality of most teams—none of the *virtual* teams will communicate solely virtually (and even if so, they will most likely vary the type of media they use) and members of *traditional*, colocated teams will rarely never use any type of virtual medium when communicating. Accordingly, we highly support recent studies claiming that all organizational teams can be considered as virtual to some extent (e.g., Kauffeld et al., 2016; Kirkman et al., 2012). Moreover, the illusory FtF-virtual dichotomy appears to distort results with regards to the influence of virtuality. As a meta-analysis by de Guinea et al. (2012) revealed, negative effects of virtual communication seem to disappear when conceptualized as a continuous measure. This is of course likely to coincide with effects for long-

term and field studies, but we consider this to support, rather than diminish the relevance of this finding. Studies using virtuality as a categorical measure are more likely to be experiments with stronger manipulations, thus augmenting effect sizes, whereas continuous measures are more likely to arise from long-term survey studies in the field, thus providing more realistic insights into the actual nature and effect of virtual communication (cf. de Guinea et al., 2012). Consequently, our second aim is to conceptualize communication as a continuous score, ranging from more to less virtual.

As evident from the definition given earlier on in the paper, we consider media use an integral part of virtuality and thus of communication in teams in general. Furthermore, albeit the elaborations on the shortcomings of MRT, the concept of media richness does not lose its validity, it is simply challenged with regards to its static conceptualization and assumed effects. Thus, the problem is not the concept of physical media properties—which have certain capacities for transmitting and processing information—but rather its equation to perceived richness as well as the static assumption of certain task-technology fits ignoring appropriation and adaptation. Accordingly, we do not dismiss media richness per se—it just has to be regarded in conjunction with other aspects of communication behavior. One of these is communication intensity.

Several studies have operationalized communication in virtual teams in form of communication intensity, for instance linking intensity to project performance (Badir, Büchel, & Tucci, 2012; Yan & Dooley, 2013). Recent studies on virtual teams have employed composite scores combining a variety of different indicators considered relevant for team processes and outcomes (Ganesh & Gupta, 2010; Hoch & Kozlowski, 2014), thus offering a continuous score incorporating multiple dimensions of virtuality. Adopting this approach of building a multidimensional composite score, we consequently propose that a conglomerate measure which allows for compensatory adaptation should be the most appropriate in measuring communication in actual teams. By combining communication intensity and physical media richness in a compensatory (i.e., multiplicative) fashion, we allow for a higher degree of communication intensity to compensate for a lower degree of physical media richness and vice versa.¹ To provide a concrete example: if one were to use an e-mail to communicate, composing it in such a fashion that it contains as much and detailed information as possible (i.e., compensating a lean medium with high communication intensity) would augment the communication score (cf. Riethmüller & Boos, 2011). This conceptualization of compensatory adaptation corresponds to findings of higher effort and contribution length in studies on adaptive media use (Fuller & Dennis, 2009; Kock, 1998, 2005, 2007).

8. A new measure of virtual communication

The communication score we aim to develop and showcase in this study thus builds on the following propositions: (1) individuals *alter* their communication behavior, (2) individuals demonstrate *compensatory adaptation* in their communication behavior via substitution between physical media richness and communication intensity, and (3) the two individual constructs can be combined in a *conglomerate score*, resulting in a continuous score of communication that allows for compensatory adaptation processes. These propositions descend in their level of abstraction, with (3)—behavioral *alterations*) being nested in (2)—*compensatory adaptation*) and (2)—*compensatory adaptation*) nested in (1)—*conglomerate score* of compensatory adaptation). Accordingly, in order to demonstrate the validity of our score (3), we consider it necessary to show that compensatory behavior in form of a substitution between physical media richness and communication intensity actually takes place (2). Going back one step further, it is first and foremost necessary to show that individuals show a variation in the physical richness of the media they use as well as their communication intensity (1), as without this premise being met, there is no point in analyzing compensatory adaptation based on this conceptualization.

Accordingly, we initially assume the existence of intra- and interindividual variations in physical media richness and communication intensity. In a real-life team context, individuals are

likely to show difference in these communication behaviors over time, depending on their communication partners, and finally as a function of both (i.e., changing behavior toward communication partners over time). This leads us to our first three hypotheses:

H1: Individuals show changes over time in (a) communication intensity and (b) physical media richness.

H2: Individuals show differences in (a) communication intensity and (b) physical media richness depending on their communication partners.

H3: Individuals show changes in their differences of (a) communication intensity and (b) physical media richness toward communication partners over time.

In a next step, we assume that compensatory adaptation is reflected in high levels of communication at low levels of physical media richness. Moreover, even though this is not explicitly addressed by CAT, we assume that this also applies for the opposite case: low levels of communication at high levels of physical media richness. While most physically rich media may appear more “natural” (cf. e.g., Kock, 1998, 2001), they are also generally associated with a higher degree of “organizational effort”, e.g., fixing a time and place for everyone to meet up (cf. Walther & Parks, 2002). Accordingly, even under CAT’s premise that more natural media require less cognitive effort, this may apply to communication itself, but not necessarily the circumstances under which it takes place. Adding a high level of communication intensity to the equation may thus lead a situation of effortful, or perhaps even strenuous communication. In turn, lowering communication intensity in these situations may be considered as adaptive behavior, as the additional “organizational effort” is compensated via less intense communication. Accordingly, we hypothesize that combinations of high levels of communication intensity at low levels of physical media use as well of high levels of physical media use at low levels of communication intensity can be found in our data. However, at the level of individual factors, media choice and adaptation will be guided or constrained by individual preferences for using particular media in particular ways, as well as by one’s skill in doing so (Barry & Fulmer, 2004; Westmyer, DiCioccio, & Rubin, 1998). Thus, compensatory adaption will be shown by some, but not by all individuals. Considering that there is no fixed benchmark with regards to the extent of compensatory behaviors, we will phrase this in form of a proposition, rather than as a testable hypothesis. Accordingly, we propose that

P1: Individuals show compensatory adaptation, in form of either a combination of high levels of communication intensity at low levels of physical media richness or of high levels of physical media richness at low levels of communication intensity

Finally, we arrive at our continuous measure of communication, which is a conglomerate of both physical media richness and communication intensity. Here, we assume that this score—which acts as a continuous and multidimensional measure of (virtual) communication and furthermore allows for compensatory adaptation processes between physical media properties and communication intensity—is optimal for accounting for both individual as well as team performance. Combining physical media richness and communication intensity in one score means that low levels of the score equal both low communication intensity as well as low physical media richness, whereas high levels of the score equal both high communication intensity and physical media richness. Compensation strategies, in turn, would result in medium levels of the score. If one were to assume a linear relationship between our score and performance, this would imply “the more the better” in every sense, i.e., using physically richer media as well as communicating

intensely. However, from a practical standpoint, this would not make any sense: One of the main advantages of communication technologies is that they save money, time, and energy, while increasing our own flexibility (e.g., Gilson et al., 2015; Hertel et al., 2005). We no longer have to travel or commute to exchange knowledge and ideas, we can do so from wherever we want, whenever we want. Moreover, even if we did want to physically meet up with other team members, meetings cannot be held on the spur of the moment. Accordingly, even if it rationally made sense (or seemed more natural, cf. e.g., Kock, 1998, 2001) to meet up FtF, this does not mean that people would actually do so—which is exactly where our compensatory mechanisms would kick in. Moreover, always opting for FtF meetings as well as simultaneously communicating intensely seems unnecessarily strenuous. In fact, overt communication, which may be reflected in a high degree of perceived intensity, reflects explicit coordination processes. Implicit coordination, in turn, is based on unspoken assumptions and intentions and can be regarded as time and energy-saving (e.g., Espinosa, Lerch, & Kraut, 2002; Wittenbaum, Vaughan, & Strasser, 2002). Accordingly, opting for both physically rich media as well as high communication intensity is likely to be perceived as effortful and demanding, thus leading to lower performance evaluations. On the other hand, considering the importance of communication for, e.g., relation management and knowledge sharing (e.g., de Vries, van Den Hooff, & de Ridder, 2006; Maruping & Agarwal, 2004), choosing media low in the variety of communication cues (i.e., physically leaner media) without compensating with a higher degree of communication intensity also appears to be detrimental for team performance. Consequently, one may expect a quadratic, rather than a linear relationship, with medium levels of the score (i.e., those symbolizing compensatory adaptation) leading to the highest performance evaluations.

H4: There is a positive quadratic relationship between the degree of communication—in form of a score incorporating both physical media richness and communication intensity—and team performance.

However, having emphasized its critical role on group processes so strongly throughout the theoretical background, we cannot leave time out of the equation. To acknowledge the dynamic nature of communication, we need to concede that there may exist not only one relationship between a process and an outcome but several. This goes back to Marks, Mathieu, and Zaccoro's (2001) temporally based framework of team processes, which assumes that “team performance trajectories most commonly consist of several I-P-O-type cycles” (p. 359). Looking at project teams, time is especially important, as it defines their very existence (e.g., Katzenbach & Smith, 1993; Kozlowski & Bell, 2001)—project teams are “temporary entities that execute specialized time-constrained tasks and then disband” (Kozlowski & Bell, 2001, p. 336). Accordingly, considering not only the fact that over time perceptions of richness/naturalness will change as a function of experience, shared understanding, and adaptation skills (e.g., Carlson & Zmud, 1999; DeRosa et al., 2004; Kock, 1998), it is also likely that the degree to which communication influences performance also changes. In accordance to our previous reasoning, we assume that individuals will become more skilled at compensating physically leaner media. Hence, we hypothesize that the quadratic nature of the function will increase over time, leading to our sixth and final hypothesis:

H5: Time will moderate the positive quadratic relationship between the degree of communication—in form of a score incorporating both physical media richness and communication intensity—on team performance to the extent that this relationship becomes stronger over time.

9. Method

9.1. Participants and procedure

Data were collected from software engineering students, who worked on a software project as a compulsory part of their curriculum. The sample comprised 165 students nested in 34 teams. The

team members' ages ranged from 19 to 34 years ($M = 22.94$, $SD = 3.21$). 89.6% of the team members were male. The participants were randomly assigned to their teams, within the limits of balanced experience backgrounds. Within the context of this course, students were to respond to the assignment of developing a software program for a particular client. These assignments included an online shop, translation tool or game. While some groups received assignments on the same topic, they all designed and implemented different programs. Albeit differing in their tasks as well as which customer they were assigned to, all teams followed a similar development process, their work thus being considered as comparable.

Data were gathered at weekly intervals over the course of the 3-month-project, resulting in a total of 14 measurement points. As we decided to exclude values from weeks 10 and 11, due to the holidays, we performed our analyses on data gathered from 12 weeks in total. Teams were expected to organize themselves independently and autonomously, deciding when and where to meet and how to interact with the customer on their own initiative. They were also free to choose which medium their preferred to communicate with at any given time.

9.2. Measures

Communication intensity, physical media richness, and the conglomerate communication score are measures obtained via a communication matrix in which every team member was asked to assess the communication intensity and media use between him- or herself and all other team members. Team members received online questionnaires which contained the question "How did you work together this week?", followed by a matrix containing the other team members' names in the rows and (1) intensity (i.e., the response format as explained below, entitled "intensity") and (2) media use (i.e., range of different media that could have been used) in the columns. These one-item measures to assess communication intensity and media use are adapted from work by Hoegl and Wagner (2005) as well as Yan and Dooley (2013). The matrix approach is derived from social network analysis, which allows analyses of social interactions, and in this case also the media usage of all involved team members. This method consequently leads to directed communication matrices, i.e., matrices containing two values for each communication pair, one from each team member's perspective. Subsequently, these are reduced to undirected matrices (the procedure varies in accordance to the investigated score, see below), thus arriving at a more holistic (and—ideally—objective) representation of an individual's communication than if individuals were simply asked to report on their overall team communication.

We calculated our scores using a procedure first introduced by Schneider, Liskin, Paulsen, and Kauffeld (2015) for measuring communication in software development teams. However, in Schneider et al.'s (2015) study, the measures were calculated at the team level. The individual calculations, as we will employ in this study, are explained in detail below and are also depicted in Figure 1.

9.2.1. Communication intensity

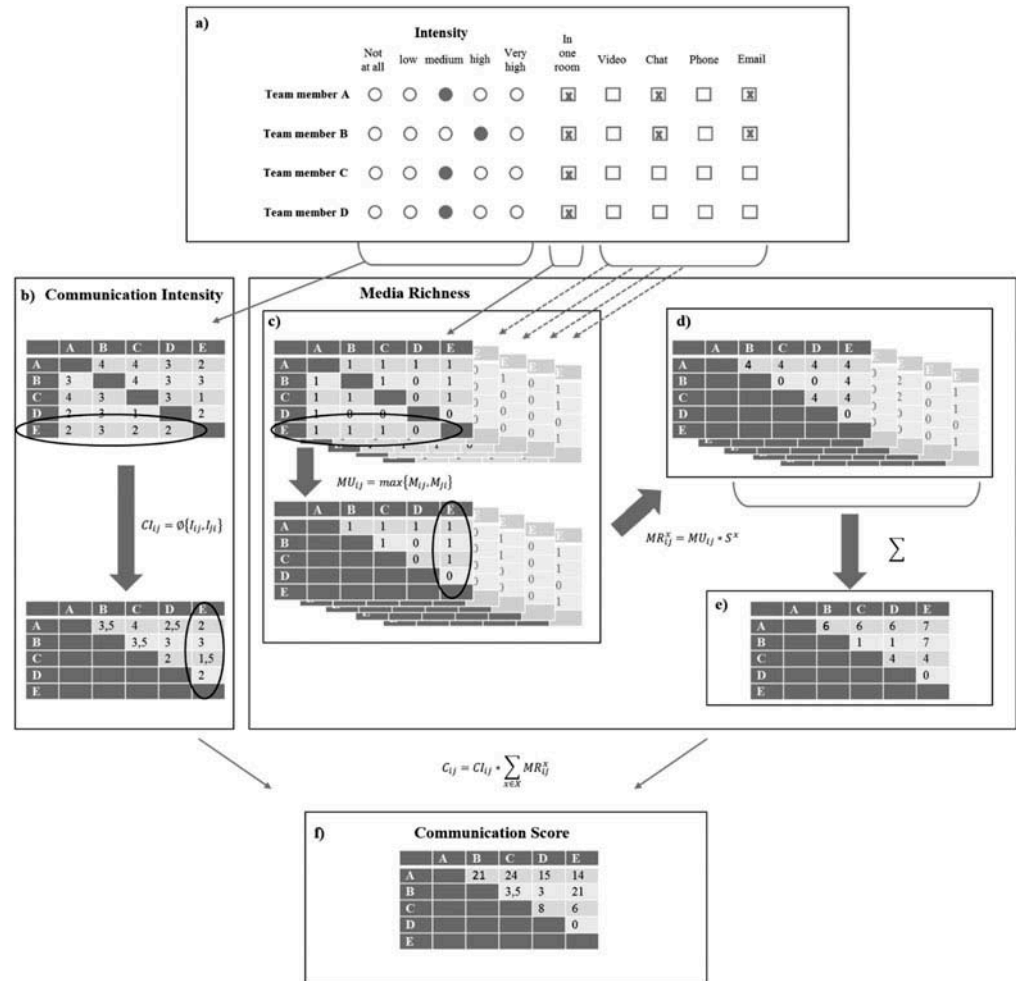
Perceived intensity of communication was rated on a scale of 0 (*not at all*) to 4 (*very high*). In a next step, the team members' ratings of directed communication were reduced to undirected scores for each communication pair within each team by averaging the two pairwise scores for communication intensity.

9.2.2. Physical media richness

The options for the media they had used in communicating with each of their team members consisted of *in one room*, *video*, *chat*, *telephone*, and *e-mail*. *Video* referred to videoconferencing, e.g., via Skype. *Chat* referred to quasi-asynchronous communication that took place via computer or mobile devices (e.g., smartphone) in a one-on-one or multiple-member setting. Examples include Skype chat, WhatsApp, Facebook messenger, or "SMS" (short message service). The response was either *yes* or *no*. Multiple answers were possible. To arrive at the undirected matrix of pairwise communication, the maximum value for each communication pair was chosen.

Figure 1. Exemplary illustration of a completed questionnaire from team member E's point of view (a), followed by the initially directed, then undirected communication matrices obtained for communication intensity (b), and media use (c). Media use (c) is subsequently weighed with the respective richness coefficients for each medium to obtain the physical media richness matrix (d), which is then summed up (e) and multiplied with communication intensity (b) to result in the final communication matrix (f).

I_{ij} = directed communication intensity rating for a pair (i, j) from I's point of view.
 I_{ji} = directed communication intensity rating for a pair (i, j) from J's point of view.
 CI_{ij} = undirected communication intensity for a communication pair (i, j), MU_{ij} = undirected media use for a communication pair (i, j).
 M_{ij} = directed media use assessment for a pair (i, j) from I's point of view. I_{ji} = directed media use assessment for a pair (i, j) from J's point of view. S^x = media richness coefficient for a given medium x. MR^x_{ij} = undirected physical media richness score for a communication pair (i, j), which equals the undirected media use score for said pair weighed with the respective media richness coefficient S^x . C_{ij} = undirected communication score for a pair (i, j), which equals the product of the undirected communication intensity and the sum of all undirected physical media richness scores for said communication pair.



Considering the binary format, the maximum value was 1, i.e., yes. The assumption behind this procedure is that forgetting to have communicated with someone is more likely than to have made it up. Subsequently, values from 4 to 1 were assigned, based on the medium's assumed informational richness, with FtF communication receiving a value of 4, video calls 3, chat and telephone 2, and e-mail 1 (cf. Schneider et al., 2015). To obtain the score for media richness of each communication pair, we calculated a weighted cumulative value of all media they had used in their interaction. Summing up the media used is based on the theoretical assumption that using a combination of leaner media can enhance shared understanding in teams (cf. Bélanger & Watson-Manheim, 2006). The concept of a cumulative score of communication media rated by

their respective media richness can furthermore be found in Ganesh and Gupta's (2010) virtuality index.

Hence, if a pair had indicated to have communicated via FtF interaction as well as chat and e-mail, their physical media richness score would be 4 (for FtF) + 2 (chat) + 1 (e-mail) = 7 .

9.2.3. Conglomerate communication score

In order to calculate the conglomerate communication score, the communication intensity and physical media richness values for each communication pair were multiplied. For example, if a communication pair had an intensity value of 4 (very high) and had communicated solely via chat, the product would equal $4 * 2 = 8$.

9.2.4. Team performance

Team performance was assessed by a measure of team productivity from Lehmann-Willenbrock, Grohmann, and Kauffeld (2011), adapted from Kirkman and Rosen (1999). Six items were rated on a five-point scale, ranging from 1 (totally disagree) to 5 (totally agree; $\alpha = .95$). A sample item is "Our group exceeds its quantitative and qualitative aims".

9.3. Data analysis

As further data processing prior to analysis depended on the hypothesis in question, we will partition our elaborations in accordance to the hypotheses into the following subsections:

9.3.1. Hypotheses 1–3

Having arrived at the pairwise scores as explained in the "Measures" section, each individual was assigned to $n - 1$ (with n being team size) number of dyadic data sets for physical media richness and communication intensity (as well as of the conglomerate score, which was not relevant for these hypotheses) for all 14 measurement points. For a member of a team of five, this would thus amount to $4 * 14 = 56$ data points for said individual. To test the first three hypotheses, we performed a two-factor repeated measures ANOVA (with communication partner and time as the within-factors), with team affiliation as a between-subjects factor in order to control for team membership influences. Hypothesis 1 was thus tested via the main effect of time, hypothesis 2 via the main effect of communication partner, and hypothesis 3 via their interaction effect.

9.3.2. Proposition 1; Hypotheses 4 and 5

In order to determine the individual score, the sum of all pairwise communication scores in which a team member participated in was calculated. This sum was subsequently divided by the theoretical maximum (for further information on the calculation of the theoretical maxima, see Schneider et al., 2015), arriving at the final, standardized individual score.

For communication intensity, the theoretical maximum for a member in a team of five is 16 , as this would reflect maximal communication with all other (four) team members, i.e., $4 * 4$ (maximal value for communication intensity) = 16 . To obtain an individual's physical media richness score, all values of their pairwise physical media richness were added. Finally, this sum was divided by the theoretical maximum of 48 (in a team of five people). Here, a score is at its maximum if a team member has communicated with all other team members using all possible media, i.e., $4 * (4 + 3 + 2 + 2 + 1) = 48$. For the conglomerate score, all pairwise products of communication intensity and physical media richness (see "Measures" section) were summed up. This sum was subsequently divided by the theoretical maximum (192 for a five-person team), arriving at the final individual conglomerate communication score. As previously explained, multiplying communication intensity and physical media richness allows high communication intensity to compensate for low media richness and vice versa. Accordingly, a person could arrive at the same score if she or he were to communicate via FtF interaction at a moderate intensity (e.g., communication intensity score of 3 , thus arriving at $3 * 4 = 12$) as if she or he communicated at a high intensity but only using leaner media such as chat or e-mail ($4 * (2 + 1) = 12$).

9.3.2.1. *Proposition 1.* Based on the idea that compensatory adaptation is reflected in high levels of communication intensity at low levels of physical media richness and vice versa, we calculated a dichotomous score reflecting adaptation (i.e., yes or no). As we were generally interested in whether compensatory adaptation took place, we calculated an overall measure. To do so, we first calculated individual values of communication intensity and physical media richness as explained above. In a first step, we categorized values on both variables into values lower or equal to/higher than .5 (as the score showed a theoretical range of 0 to 1, .5 thus constituting the theoretical half), thus leading to four categories (high/low communication intensity and high/low physical media richness). Subsequently, we calculated our measure of compensatory adaptation, where cases showing both high communication intensity and low physical media use as well as both low communication intensity and high physical media use were grouped into the category “yes” and the rest (i.e., high/high and low/low) into “no” (cf. Table 3). As we were merely interested in seeing the distribution of compensatory vs. non-compensatory behaviors, reporting descriptive statistics adequately serves this purpose.

9.3.2.2. *Hypothesis 4 and 5.* Considering the nestedness of our data (time points nested in individuals nested in teams), a multilevel structural equation modelling approach using Mplus version 7.1 (Muthén & Muthén, 1998–2013) was chosen to test Hypotheses 4 and 5. This approach helps to avoid problems such as measurement errors in (level 2) covariates (information from data points within clusters reflecting cluster characteristics) as well as unobserved heterogeneity among individual measures due to unobserved but similar background characteristics (Muthén & Asparouhov, 2011). This allowed us to investigate intraindividual relationships (i.e., between communication and team performance over the various measurement points) while controlling for individual and team-level dependencies. Accordingly, we constructed three-level models to test our hypotheses. Specifically, we regressed individual team performance ratings on (a) the conglomerate communication score as well as (b) the conglomerate score’s quadratic term (having centered the conglomerate score on its grand mean prior to multiplication in order to avoid multicollinearity). This was done on L1 (level one, here: intraindividual level), while controlling for cluster-related dependencies of the dependent variable (team performance) on L2 (level two, here: interindividual level) and L3 (level three, here: team level).

In order to test the moderating role of time (Hypothesis 5), we created an interaction term (after having centered the variables) between time point and the quadratic conglomerate communication score, and additionally regressed team performance time point as well as on the interaction term on L1.

We used the maximum likelihood estimation with robust standard errors (MLR) and full-information maximum likelihood for all analyses.

10. Results

10.1. Hypothesis 1–3

10.1.1. Communication intensity

We performed Mauchly’s test of sphericity prior to interpreting the results of the repeated measures ANOVA. Due to significant results both for the factor time as well as for the interaction between time and communication partner, we chose Greenhouse–Geisser corrected values for interpreting the main effect of time as well as the interaction effect. The results of our two-factor repeated measures ANOVA showed a significant main effect of time ($F(8.72, 1082.16) = 192.83$, $p < .001$) and communication partner ($F(3, 372) = 6.48$, $p < .001$), thus lending support to Hypotheses 1a and 2a. We also found a significant interaction effect between time and communication partner ($F(20.75, 2573.46) = 2.51$, $p < .001$), thus also supporting Hypothesis 3a.

Our results also showed a significant between-subjects effect of team affiliation ($F(30, 124) = 11.47$, $p < .001$), as well a significant interactions between team affiliation and communication partner ($F(90, 372) = 3.82$, $p < .001$), time ($F(261.81, 1082.16) = 5.94$, $p < .001$), as well as a

significant three-way interaction between team affiliation, communication partner, and time ($F(622.61, 2573.46) = 3.00, p < .001$).

10.1.2. *Physical media richness*

Mauchley's test of sphericity also revealed significant results both for the factor time as well as for the interaction between time and communication partner with regards to physical media richness. Accordingly, we chose Greenhouse-Geisser corrected values for interpreting the main effect of time as well as the interaction effect. The results of the ANOVA showed a significant main effect of time ($F(8.19, 1015.17) = 42.16, p < .001$), thus supporting Hypothesis 1b. The main effect of communication partner, however, did not reach significance ($F(3, 372) = 2.44, p = .064$). Hypothesis 2b was thus rejected. As we found a significant interaction effect between time and communication partner ($F(20.02, 2482.25) = 2.41, p < .001$), Hypothesis 3b was supported.

Our results also showed a significant between-subjects effect of team affiliation ($F(30, 124) = 23.29, p < .001$), as well as significant interactions between team affiliation and communication partner ($F(90, 372) = 3.51, p < .001$), time ($F(245.61, 1015.17) = 11.56, p < .001$), as well as a significant three-way interaction between team affiliation, communication partner, and time ($F(600.55, 2482.25) = 2.71, p < .001$).

10.2. *Proposition 1; Hypotheses 4 and 5*

Means, standard deviations, and intraclass correlations (ICC) for the individual scores are presented in Table 1, intercorrelations are presented in Table 2.

10.2.1. *Proposition 1*

Table 3 shows the percentages of adaptive behaviors. As we can see, there is a consistent display of adaptive behaviors, with at least one third (and often more than half) of all individuals showing adaptive behaviors over all time points. While not explicitly formulated in proposition one, we also analyzed the type of adaptive behavior, i.e., whether it resulted from low values of communication intensity at high values of physical media richness or vice versa. Overall, the distribution between the two subcategories shows that the majority of adaptive behaviors as we defined them are constituted by high levels of communication intensity at low levels of media richness.

10.2.2. *Hypotheses 4 and 5*

As indicated by the ICC values in Table 1, unit membership explains a large amount of individual variations in all our measures. Accordingly, controlling for both dependencies within individuals as well as within groups in form of multilevel modeling can be considered as justified in our case measure (Bliese, 2000). The results of the multilevel analyses are displayed in Table 4. The first model, which regressed team performance on the conglomerate communication score as well as on its quadratic term attained an excellent model fit ($\chi^2 = .000, SRMR_{within} = .000, SRMR_{between} = .000, CFI = 1.000; RMSEA = .000$, cf. Wang & Wang, 2012). As can be deduced from Table 4 (model 1), values for both the conglomerate score ($B = .693, p = .001$) and its quadratic term ($B = -.956, p = .022$) were significant and in the expected direction. Hypothesis 4 was thus supported. Next to the conglomerate score and its quadratic term, the second model also regressed team performance on time point as well as the interaction between the quadratic conglomerate score and time point. The model also displayed excellent fit values ($\chi^2 = .000, SRMR_{within} = .000, SRMR_{between} = .000, CFI = 1.000; RMSEA = .000$). As also reported in Table 4 (model 2), the quadratic term lost its significant main effect ($B = .285, p = .600$). There was also no significant main effect of time point ($B = .020, p = .157$). The effect of the moderation term, however, reached statistical significance and went into the expected direction ($B = -.183, p = .012$). We consequently performed simple effects analysis to obtain a better understanding for the influence of time on the effect of the quadratic term on team performance. Accordingly, we calculated the conditional effect of the quadratic term on team performance at low (week 1; $B = 0.102, p = .837$), medium (week 6; $B = -0.812, p = .045$), and high (week 14; $B = -1.908, p = .003$)

Table 1. Means, standard deviations, and intraclass correlations

Week	Variables											
	Communication Intensity			Physical Media Richness			Conglomerate Score			Team performance		
	M	SD	ICC _T	M	SD	ICC _T	M	SD	ICC _T	M	SD	ICC _T
1	.66	.15	.67	.46	.09	.62	.31	.08	.44	3.72	.66	.14
2	.74	.12	.56	.45	.10	.75	.35	.09	.63	3.79	.69	.21
3	.75	.14	.53	.49	.12	.64	.38	.12	.55	3.73	.76	.28
4	.72	.15	.31	.49	.12	.57	.37	.12	.55	3.84	.75	.16
5	.74	.14	.63	.49	.12	.75	.37	.12	.70	3.79	.74	.19
6	.72	.16	.77	.47	.12	.80	.36	.13	.79	3.80	.79	.26
7	.66	.17	.69	.47	.16	.80	.33	.16	.76	3.79	.81	.19
8	.59	.20	.78	.46	.16	.78	.29	.16	.84	3.66	.89	.20
9	.52	.19	.66	.43	.16	.73	.26	.14	.72	3.67	.87	.24
12	.74	.16	.74	.53	.15	.83	.41	.17	.85	3.49	.98	.33
13	.74	.16	.61	.52	.14	.81	.40	.15	.74	3.68	1.01	.31
14	.53	.23	.70	.43	.18	.74	.27	.16	.71	3.85	1.08	.36
ICC _w	.04			.02			.04			.45		

Notes: N = 165 individuals. M = mean. SD = standard deviation. ICC_T = intraclass correlation coefficient for team affiliation. ICC_w = intraclass correlation coefficient for the individual level (intraperson variation over time).

Table 2. Intercorrelations

Variable	Conglomerate score													
	Week	1	2	3	4	5	6	7	8	9	12	13	14	
Team performance	1	.11	.04	.03	-.06	.19*	.05	-.11	-.10	-.10	-.01	-.10	-.00	
	2	.04	.30**	.14	.04	.15	.07	-.01	-.00	-.19*	.15	.16*	.13	
	3	.03	.29**	.20*	.07	.17*	.09	-.08	-.03	-.18*	.14	.13	.13	
	4	.02	.14	.12	-.02	.11	-.03	-.04	-.03	-.13	.07	.05	.13	
	5	.10	.23**	.18*	-.00	.19*	-.01	.02	.03	-.11	.11	.09	.15	
	6	.07	.14	.12	-.14	.12	.02	-.15	.01	-.15	.08	-.03	.14	
	7	.06	.13	.11	-.08	.12	.06	-.05	.03	-.11	.03	-.03	.09	
	8	.08	.16*	.13	-.04	.14	.08	.01	.09	-.09	.06	.07	.15	
	9	.00	.08	.08	-.03	.15	.09	-.04	.07	-.13	.09	.08	.10	
	12	.04	.04	-.09	-.13	-.01	-.00	-.17*	-.02	-.10	-.04	-.11	-.09	
	13	.10	.03	-.07	-.06	.01	.01	-.12	-.02	-.09	.03	-.04	-.07	
	14	-.06	.01	-.05	-.06	.05	.05	-.14	-.11	-.15	.02	-.02	.02	

Notes: N = 165 individuals. *p < .05 (two-tailed), **p < .01 (two-tailed).

Table 3. Adaptation frequencies

Week	Adaptation			
	No	Total	Yes	
			Low/high	High/low
1	35.2%	64.8%	5.5%	59.4%
2	38.2%	61.8%	2.4%	59.4%
3	53.3%	46.7%	0%	46.7%
4	56.4%	43.6%	0%	43.6%
5	43.0%	57.0%	1.2%	55.8%
6	44.8%	55.2%	1.8%	53.3%
7	59.4%	40.6%	1.2%	39.4%
8	64.2%	35.8%	7.3%	28.5%
9	64.8%	35.2%	5.5%	29.7%
12	63.0%	37.0%	2.4%	34.5%
13	63.0%	37.0%	1.8%	35.2%
14	66.1%	33.9%	5.5%	28.5%

Notes: N = 165 individuals. Values indicate percentages of total communication behavior. Low/high = low communication intensity and high physical media richness. High/low = high communication intensity and low physical media richness.

Table 4. Estimates for the multilevel regression analysis predicting team performance

Predictor variables	Model 1		Model 2	
	Estimate	95% CI	Estimate	95% CI
Conglomerate score	0.693 (.243)	[0.268; 1.119]	0.708 (. 248)	[0.284; 1.131]
Conglomerate score ²	-0.956 (-.201)	[-1.773; -0.140]	0.285 (.060)	[-0.779; 1.348]
Time point			0.020 (. 131)	[-0.007; 0.047]
Conglomerate score ² x time point			-0.183 (-.332)	[-0.325; -0.040]
R ²	.01*		.03**	

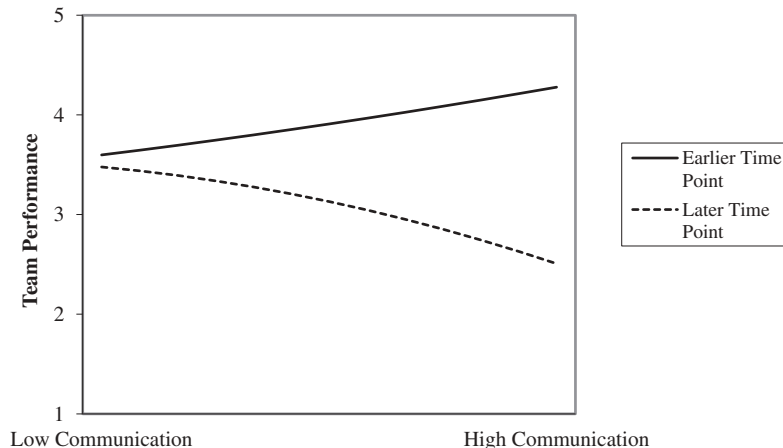
Notes: CI = confidence interval. Conglomerate score² = quadratic term (the conglomerate score was grand-mean centered prior to creating the product term). Standardized estimates are given in parentheses. Model 1 = regression of team performance on the conglomerate score and its quadratic term (H4). Model 2 = regression of team performance on the conglomerate score, its quadratic term, time point and the interaction between time point and the quadratic term (H5). Level 1 N (number of observations) = 1911, level 2 N (number of individuals) = 165, level 3 N (number of teams) = 34. For R² = *p < .05 (two-tailed), **p < .10 (two-tailed).

levels of the moderator, showing an increase in the quadratic trend over time. Accordingly, Hypothesis 5 could be supported. An illustration of the effect can be found in Figure 2.

11. Discussion

By showing individual alterations of both communication intensity and media use depending on communication partner and point in time, our results show that individuals dynamically adapt their communication behavior. Moreover, we presumed that adaptive virtual communication relies on compensatory processes between physical media properties and communication intensity. Our descriptive results show that adaptive behaviors, as per our definition of high levels of communication intensity at low levels of physical media richness (and vice versa), are consistently displayed, at times by more than half of our sample. Moreover, the descriptive statistics also show that adaptive behavior can largely be seen as high communication intensity at low physical media richness levels, a result that is consistent with prior studies (e.g., Kock, 1998, 2007), assuming an increase in communicative effort in order to compensate for physically leaner media.

Figure 2. Depiction of the effect of the conglomerate communication score on team performance at low (i.e., week 1) at high (i.e., week 14) levels of the moderator point in time.



Building on the fact that individuals show alterations in communication intensity and physical media richness in response to communication partners and points in time and that these occur in a complementary fashion (i.e., high levels of communication intensity at low levels of physical media richness), we constructed a measure that allowed for compensatory processes between these two variables. The next step in establishing our adaptive communication measure was to prove its validity, for instance by showing a relationship to criterion variables, such as team performance ratings. Our results were able to show not only a linear but also a quadratic influence of our conglomerate (i.e., communication intensity \times physical media richness) score on team performance ratings. Accordingly, while low values of both communication intensity and physical media richness were linked to lower performance evaluations, more of both did not generally translate into better performance. Thus, medium levels of the conglomerate score, which would translate into compensation strategies, led to higher team performance evaluations than high levels (signifying both high communication intensity and physical media richness). This confirms our theory that the high organizational effort of physically rich media such as FtF meetings, may be exacerbated by simultaneously high levels of communication intensity. Moreover, our results show that this quadratic trend is especially true for later time points, i.e., when team members have already spent a considerable amount of time working with each other. At this stage, high levels of the score suggest that members are exerting a great deal of effort into explicit communication by choosing physically rich media and communicating intensely. Especially at a stage of collaboration where—due to increased experience with the task, other team members and communication channels—individuals should be expected to show adaptive communication behavior, high levels may in fact imply that something is not going the way it is supposed to.

In sum, our study emphasizes individuals as active users who dynamically appropriate media to their cause rather than being passively subjected to media's static and rigid characteristics. By not only conceptualizing but also measuring virtual communication in a way that accounts for adaptive behaviors, we consider our study to provide an important theoretical contribution to communication and virtual team research. Moreover, our results also possess important implications for practitioners who seek to understand the influence of communication media on collaboration and avoid communication breakdowns in teams.

11.1. Theoretical implications

Our study implies that individuals show adaptive communication behavior under consideration of media use. As asserted by models of social influence (e.g., Fulk et al., 1990; Walther, 1992, 1996) individuals show social awareness when communicating—they know who they are talking to about what and realize that this determines the way they ought to communicate. As our results show, the extent to which individuals show different behaviors toward other communication

partners isn't constant but differs between the respective time points. Accordingly, individuals also *change* the differential way they communicate with others. This finding supports the mechanisms proposed in CET (Carlson & Zmud, 1999), which argues that individuals enhance channel richness perceptions via the knowledge-building experiences they gain with regards to topic, communication partner and channel. The changes we observed in both choice of communication medium and intensity it is used with may in fact constitute situations where differential knowledge on channel use is built. Moreover, we extend CET's postulations and findings by analyzing several communication channels and dyadic interaction nested in teams.

By demonstrating the dynamic variation in input factors (e.g., choice of medium), our findings thus challenge the classic task-technology-fit approach to analyzing media effects. As we elaborate in our study, we consider adaptive communication processes as a key variable in explaining the dynamics in CMC effectiveness. Our findings show that individuals display a moderate to strong tendency to exhibit high communication intensity at low levels of physical media richness. This not only corresponds to CAT, which argues for a higher communication effort (due to improved de- and encoding of messages) when using leaner media (e.g., Kock, 1998, 2001) but also supports prior findings showing longer contributions in CMC over FtF (e.g., Fuller & Dennis, 2009; Kock, 1998). The quadratic relationship we found between our conglomerate measure and team performance supports prior findings showing that compensatory effort does not impair team performance (Kock, 1998, 2005). On the contrary—using leaner media may also decrease organizational effort and be more convenient. When used in a fashion that enhances subjective channel richness, e.g., via increased encoding effort, they may thus be an optimal choice. Moreover, as individuals improve their de- and encoding skills and as teams reach a shared understanding of joint goals and tasks, thus improving their coordination, compensatory effort may generally decrease over time—a postulation supported by the increased quadratic trend we observed in our data.

In sum, our key theoretical implication is that the way media are used and perceived is dynamic. Individuals do not have to be passively restricted to physical properties imposed by technological design but can learn to appropriate media in a target- and situation-specific manner. Our study thus contributes to a dynamic person-task-technology fit perspective, where media use and effects are less a function of physical properties than of media appropriation and perception.

11.2. Practical implications

Our study essentially argues for the importance of compensatory adaptation processes in CMC. While traditional CMC models, such as MRT (Daft & Lengel, 1986) or SPT (Short et al., 1976), postulate the existence of a rationally correct choice of medium, we argue that reality looks very different. First of all, the development of virtual communication media is based on very practical reasonings: we no longer have to be in the same place at the same time. Among many other advantages, this not only saves office space and commuting time but also means being able to reconcile work and family obligations due to more flexible work arrangements such as teleworking. Accordingly, even if it rationally (from a static media richness perspective) made sense to meet up FtF, this may be highly unpractical in reality. This is exactly where media appropriation and thus compensatory mechanisms play an essential role. By enhancing richness perceptions of leaner media via adaptive, compensatory behavior, individuals can very well achieve both work flexibility and effective communication at the same time. Accordingly, both team members as well as management should ensure effective media appropriation strategies. For example, management could offer courses on effective en- and decoding strategies using leaner media. This could include explaining the relational effects of seemingly matter-of-fact statements in a context without nonverbal or paraverbal cues and suggesting possibilities of substituting these, e.g., via explicit verbalization of possible connotations. For example, emoticons can be added to ambiguous messages, or “softeners” can help manage the relational perspective of otherwise strongly task-focused CMC.

Training compensatory adaptation does not necessarily have to occur solely “off-the-job”. Learning may also take place in form of trying different communication media in different situations or testing out different styles of writing messages, while regularly reflecting the effect it has on oneself or seeking feedback from others. This can take place on an individual, autodidactic level but can also be encouraged in a team context.

Lastly, the best way of learning how to de- and encode messages is via knowledge-building experiences (cf. Carlson & Zmud, 1999; Walther, 1992). Accordingly, teams should generally allow for a certain period of their collaboration that includes getting to know one another, the task and which means of communication are best suited to particular team members and/or the team as a whole. This may be facilitated via initial team-building experiences, ideally in a FtF context, in order to speed up relationship and trust building processes (Brahm & Kunze, 2012; Powell, Piccoli, & Ives, 2004).

11.3. Limitations and directions for future research

As every study, our research possesses some limitations that may inspire future work in this area. First, we did not gather the frequency of communication in general and specifically not of the media used. When operationalizing the term virtuality, it has become increasingly popular to employ the frequency of interactions in calculations (e.g., Ganesh & Gupta, 2010; Hoch & Kozlowski, 2014). However, our approach was evidently more economical as well as less intrusive, minimizing the risk of participants altering their communication behavior due to the strain imposed by more detailed measures. Moreover, given that we see media richness less as a physical property than a function of appropriation and perception, we consider it to be fundamentally subjective. Nevertheless, considering possible biases due to memory effects or social desirability, we would encourage future research to include both subjective and objective frequency measures. The same can be said for our criterion, team performance. In order to capture the subjective influence of communication, we considered a self-reported measure as justified, however, future research including more “objective criteria”, such as the quality of the product developed during the project, the number of requirements met, or the degree of tasks performed per time unit could provide further valuable insights. Moreover, our composite approach used to capture communication could be criticized for being ambiguous with regards to the distinct components, e.g., the different media types or in the combination of media richness and communication intensity. However, while possibly neglecting the unique contributions of these components, our score combines a range of theoretically relevant aspects (e.g., media use, media richness, communication intensity, compensatory adaptation) in a parsimonious fashion. This is not only empirically supported by similar studies (e.g., Ganesh & Gupta, 2010; Hoch & Kozlowski, 2014) but also by our own data. Nevertheless, we would encourage further studies dedicated to analyzing these components and their interactions separately, given an adequately large sample size to allow for robust evaluations.

Second, we only investigated the nature and degree of communication and its influence on team performance, not the content. Therefore, our interpretations regarding the specific mechanisms which we presumed to constitute compensatory adaptation are of course speculative to the extent that we could not analyze their content. Examining structural elements, such as contribution length, duration, or distribution—as shown by in studies by Fuller and Dennis (2009), Kock (1998), or van der Kleij, Schraagen, Werkhoven, and De Dreu (2009)—could be of additional value. Taking it a step further, the communicative focus—i.e., task- vs. relationship-oriented—should also be highly relevant. While traditional cues-filtered-out theories consider CMC incapable of a high relational focus, SIP (Walther, 1992, 1996) considers the occurrence of relational communication contingent on time. CMC groups are thus just as capable of personal and social exchanges by adapting their communication via content and style (cf. Utz, 2000). Accordingly, future research should be dedicated to the analysis of task- vs. relational elements of compensatory adaptation.

Third, especially considering the significant interactions of communication over time and team affiliation, it could also be interesting to investigate which team level factors could influence these individual dynamics in more detail. While we controlled for team-level dependencies, this was not the focus of our study. However, considering that media use and effects underlie social influences (e.g., Fulk et al., 1990; Walther, 1992, 1996), there will likely be a range of potential cross-level interactions, i.e., team-level influences on individuals' compensatory adaptation processes. Especially under consideration of the salience of social identity in CMC groups as postulated by the social identity model of deindividuation effects (Postmes, Spears, & Lea, 1998, 2000), we would expect group norms to play an important role. We would thus encourage future research including multilevel conceptualizations of compensatory adaptation.

A fourth limitation is the sample in this study. Students are a fairly homogenous group and may experience less pressure than in real-life work situations. However, considering the fact that they had to develop an actual product, fit to be handed over to a customer, we still considered them to be a suitable sample for deriving real-life implications.

Lastly, we see one of our main contributions to lie in our longitudinal field design. While we analyzed the effects of time on communication processes and effects, we considered linking these to particular tasks as going beyond the scope of study. Accordingly, we consider the role of tasks or even project phases on changes in adaptive communication and its effects as a connecting factor for future research.

12. Conclusion

The aim of this study was to offer a conceptualization and measurement of virtual communication that accounts for its subjection to social and temporal influences and thus inherently dynamic nature. Our results demonstrate inter- and intraindividual variations in communication and the existence of compensatory adaptation as a function of communication intensity and physical media richness. We developed a continuous score capturing our definition of compensatory adaptation and were able to show its influence on team performance, which increased over time. In sum, we consider our research to strengthen and extend CAT by providing tangible empirical evidence in the context of a longitudinal field study.

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Note

1. Albeit not addressed in CAT, we propose that the case of compensation via low levels of communication intensity at high levels of physical media richness also serves an adaptive function (see argumentation for P1 in the next section).

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