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Videoconferencing in the Field: A Heuristic Processing Model

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This research uses dual-process cognitive theory to describe how people process information differently when it is delivered via videoconference rather than when it is delivered face-to-face. According to this theory, relative to face-to-face communication, people in videoconferences tend to be more influenced by heuristic cues—such as how likeable they perceive the speaker to be—than by the quality of the arguments presented by the speaker. This is due to the higher cognitive demands that videoconferencing places on participants. We report on a field study of medical professionals in which we found differences in information processing as predicted: participants attending a seminar via videoconference were more influenced by the likeability of the speaker than by the quality of the arguments presented, whereas the opposite pattern was true for participants attending in-person. We also found that differences in cognitive load explain these effects. The discussion on the theoretical model and associated findings explains why prior videoconference studies have not consistently found main effects for media. The findings also show that videoconferencing is not like face-to-face communication, despite apparent similarities.

Key words: computer-mediated communications; videoconferencing; cognitive workload; heuristic systematic model
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1. Introduction

Organizational videoconferencing is widely used for board meetings, investor consultations, remote legal depositions, software development, distance learning, telemedicine, and countless other applications. In fields such as telemedicine, its use is standard operating procedure. Worldwide factory revenues for enterprise videoconferencing systems are estimated to be $1.1 billion in 2008 (Davis et al. 2004). The benefits of videoconferencing include reduced travel costs, faster decision making, enhanced employee quality of life, increased productivity, improved customer relationships, faster time-to-market, better team management, and expanded global reach (Weinstein and Davis 2005). In addition to understanding the benefits of use, managers need to be clear about the ways in which video is not a seamless substitute for face-to-face communication. Prior research has not generated a consensus on this issue, hence the need for our basic research question: Are there important ways that video-based conferences are different from face-to-face conferences in organizations?

This study investigates this by using cognitive theory to highlight one critical difference between how people process new information when it is delivered via video versus face-to-face: because of the higher cognitive load of videoconferencing relative to face-to-face interaction, people using it tend to rely more on available heuristic cues. We demonstrate this difference in cognitive processing using a sample of medical professionals attending "grand rounds" seminars via videoconference or face-to-face.

The contribution of this research is threefold. First, it explains a basic cognitive mechanism underlying videoconferencing use. Second, the theory we apply has been widely utilized for laboratory experiments of persuasion, but not for understanding field-based knowledge work. We test the theory on professionals at work in the domain of knowledge transfer. Third, application of this theory to the videoconferencing context helps to reconcile previously inconsistent video-mediated communication (VMC) research findings, offering researchers a potentially integrative framework.

We begin by briefly reviewing the existing videoconferencing literature to establish that a cognitive approach to understanding videoconferencing is warranted. We then discuss the cognitive theory of the heuristic systematic model and use it to build the theoretical model and hypotheses. Next, we present

the empirical method used for data collection, followed by the data analyses. We close with a discussion of the implications and limitations of the study, and suggest avenues for future research.

2. Videoconferencing Research

Videoconferencing can reduce travel costs, improve employee productivity, and enable wider participation in decision making (Campbell 1998). It can also blur geographic boundaries, help to create a consistent corporate culture, and enhance employees' quality of life (Davids 1999). Early research on interactive video was confounded by technical problems such as blurred images and unsynchronized video and audio that today have largely disappeared. Researchers are now able to conduct empirical studies of VMC in which the quality of the technology is not a confounding factor. Four broad streams of research dominate the videoconferencing field. First, information systems (IS) researchers investigate videoconferencing as one manifestation of computer-mediated communication phenomena. Second, researchers in the field of communications examine videoconferencing using the methods and approaches of their paradigm. Third, the field of telemedicine has produced a great number of studies investigating the effects of videoconferencing on medical outcomes. From this research we know that use of VMC is clearly preferable to having no face-to-face interaction with medical practitioners, but this stream of research does not consider the basic effects of VMC on cognition. Fourth, the online learning research stream investigates the impact on learning outcomes of various new media and technologies—one of which is video—in educational contexts (e.g., Alavi et al. 1995), but does not address the basic effects of VMC on cognition. This study investigates the effects of VMC on cognition, focusing on the IS and communication-based VMC research streams.

Beginning with the IS arena, research on the effects of VMC[1] has primarily been conducted in terms of how it compares to other media and face-to-face communication. This prior research can be roughly divided into those with a media determinant perspective and those without. Media determinant theories, such as media richness and social presence theories, posit that there are characteristics of the media that are context independent and invariant over time, affecting all who use them. Most researchers now acknowledge that contextual and emergent factors, such as prior relationships among users and prior experience with the technology, affect the process of media use (e.g., Fulk 1993, Rice and Love 1987).

Nevertheless, within certain contexts, invariant properties of media continue to be found (e.g., Sussman and Sproull 1999). For developing our theoretical model, we focus on the findings of media determinant researchers, addressing the contextualized, emergent aspects of VMC in the discussion section. According to media richness theory (Daft and Lengel 1986), face-to-face communication is richer than VMC, although empirical research has not consistently supported this view (e.g., Suh and Jenkins 1992). Social presence theory posits that the more a particular medium supports transmission of interpersonal cues, the closer the communication pattern will be to face-to-face communication (Short et al. 1976). When verbal and nonverbal cues are removed there is a loss of social presence, which can make people become more self-centered (Sproull and Kiesler 1986) and lead to decision making on the basis of personalities rather than facts (Short et al. 1976). Social tasks, such as conflict resolution or negotiation, make greater use of social presence information than do nonsocial tasks such as intellectual, decision-making, or creative ones. For this reason, in the IS field, VMC is often investigated relative to the task type it is intended to support. Table 1 summarizes the findings of a number of empirical studies comparing VMC to face-to-face interaction.

In comparison with face-to-face interaction, we would expect to find that VMC is inferior for social tasks because it conveys less social presence. However, a number of studies have not been able to demonstrate the superiority of face-to-face communication for social tasks, and others report VMC superiority for both task types. An in-depth analysis of these findings is beyond the scope of this study, but Table 1 suggests that, from an IS research perspective, the understanding of how VMC differs from face-to-face communication is incomplete and bears further research. Note that none of these studies have taken a cognitive approach to understanding VMC, with the exception of the work of Alan Dennis, who has applied dual-process cognitive theory to media richness (Robert and Dennis 2005) and group support systems, but not by using field-based methodology as we do.

We now turn to videoconferencing research that has been conducted by communications researchers. Work in this stream investigates the communication process, measuring such constructs as handoffs, speed of switching between speakers, gaze, dialogue length, and outcome efficiency and effectiveness. Table 2 summarizes empirical findings in this stream related

[1] Note that this is distinct from the large stream of research on media choice and adoption, in which a number of important studies have investigated videoconferencing. Many excellent studies in this stream contribute to our understanding of the influences of VMC systems in organizations, but do not address the influence of VMC on how users process the delivered information.

Table 1 Empirical VMC Studies from the IS Domain

Study outcome	Social task	Intellective task
Face-to-face superior to video	Crede and Sniezek (2003) on enjoyment and confidence	Sumner and Hostetler (2002) on satisfaction
Face-to-face not superior to video	Suh (1999) on decision quality and task satisfaction; Crede and Sniezek (2003) on outcome quality and five other factors; Mennecke et al. (2000) on decision time, consensus change	Suh (1999); Olson and Olson (1997) on accuracy; Alavi et al. (1995) on learning and satisfaction; Mennecke et al. (2000) on decision quality
Video superior to face-to-face	Suh (1999) on satisfaction; Crede and Sniezek (2003) on number of beliefs modified	Suh (1999) on satisfication; Sumner and Hostetler (2002) on decision quality; Jonasson and Kwon (2001) on satisfaction

Table 2 Empirical VMC Studies from the Communications Domain

Study outcome	Social task	Intellective task
Face-to-face superior to video	Anderson et al. (1996) on efficiency; Doherty-Sneddon et al. (1997) on efficiency; Sellen (1995) on formality; O'Conaill et al. (1993)	O'Malley et al. (1996) on task performance; Sanford et al. (2004) on accuracy
Video superior to face-to-face		Sanford et al. (2004) on formality

to videoconferencing. With some exceptions, communication researchers have found that VMC does not offer the same benefits as face-to-face communication and can even have adverse effects. This contrasts with IS studies that have found no significant performance differences between the two, nor better outcomes for VMC than face-to-face.

3. Cognition and VMC

One area in which there is consensus on how VMC differs from face-to-face communication is that VMC increases cognitive workload even for systems that are high bandwidth and high quality (Ferran-Urdaneta and Storck 1997, O'Conaill et al. 1993, O'Malley et al. 1996, Storck 1995). Communicating via videoconference presents the challenges of difficult audio localization, turn-taking and conversation pacing, changes in cue salience, asymmetrical personal distance, and heightened self-awareness. These all increase the cognitive workload demanded from videoconference participants (Storck 1995). For these reasons, videoconferencing participants' cognitive workload tends to be higher than face-to-face participants' attending the same conference.

Cognitive workload is also a key component of the dual-process paradigm of human information processing. Dual-process cognitive theories describe the conditions and processes that take place when people accept new information as valid or discount it as invalid. These theories distinguish between two basic ways that individuals process information: systematically and heuristically. Systematic processing involves scrutinizing the argumentation of new information and analyzing it in the context of what is already known to judge its validity. Performing this detailed analysis demands and consumes cognitive capacity.[2] Heuristic processing is defined as the application of learned procedural knowledge structures—heuristics—to informational cues during assessment of received information (Chaiken 1980, Eagly and Chaiken 1993). Attitudes formed solely on the basis of heuristic processes tend to be less predictive of future behavior, less stable in time, and less resistant to counter arguments (Petty and Cacioppo 1986a). In general, both processing modes occur concurrently and exert interdependent effects on judgment (Chaiken 1980, Chaiken et al. 1989).

The dual-process paradigm evolved out of the early attitude change research of social psychologists such as McGuire (1969). The heuristic systematic model (HSM) (Chaiken 1980, Chaiken and Eagly 1983) and the elaboration likelihood model (ELM) (Petty and Cacioppo 1986a) are the most renowned variants of this perspective. ELM has been widely adopted by marketing researchers to understand what makes advertisements most persuasive. However, because the paradigm can also apply to generalized validity-seeking processes, the dual-process theories have been used to investigate a wide variety of phenomena, from auditor performance (Brazel et al. 2004) to risk perception (Trumbo 2002). They have also been used to investigate media differences in the laboratory, where media has been found to affect message vividness and communicator salience (Chaiken and Eagly 1983). Dual-process models have long been the basis of laboratory studies of mediated communication (Chaiken 1980, Chaiken and Eagly 1983, Chaiken et al. 1989), but have only recently been applied to mediated knowledge transfer in the field (Sussman and Seigal 2003).

The HSM was developed to apply to validity-seeking settings in which people are primarily motivated to attain accurate views consonant with

[2] According to Eagly and Chaiken (1993, p. 329), this view coheres with Petty and Cacioppo's (1986b) assumption that ability is a prerequisite for argument elaboration.

relevant facts (Chaiken 1980). In this study, we are interested in knowledge transfer in organizational videoconferencing contexts, and because these are validity-seeking contexts, we utilize the theory and terminology of the HSM throughout this paper. According to the HSM, people apply the least amount of cognitive capacity necessary for ascertaining the validity of received information. At this point, they reach a sufficiency threshold beyond which additional processing is unnecessary. Because heuristics are simple rules that conserve cognitive capacity, they are utilized early in the information assessment process. Where they are not sufficient to support validity assessment, the more resource intensive process of systematic processing is invoked (Chaiken and Eagly 1983, Chaiken et al. 1989). The relative emphasis on the two types of processing varies with the available cognitive capacity of the individual. The greater the cognitive capacity, the greater the likelihood that systematic processing will be undertaken if a sufficiency threshold has not been reached using heuristics. People that are highly motivated are more likely to undertake the effort of systematic processing than those that are less motivated to do so (Liberman and Chaiken 1996, Petty and Cacioppo 1986a), but it is cognitive capacity that both enables and constrains systematic processing. For this reason, researchers have identified a number of factors that increase cognitive workload and hence also the likelihood of heuristic processing relative to systematic processing. For example, background noise, interruptions, time pressure, and visual distractions have all been shown to increase cognitive workload and thus the likelihood of heuristic processing (Eagly and Chaiken 1993, Chap. 6).

3.1. Information Influence and Adoption

The HSM explains how individuals are influenced by new information, and information adoption is one potential outcome of this process. The concept of informational influence was first identified by Deutsch and Gerard (1955), but their definition is not specific. Kelman's (1961) internalization process describes its outcome: information is adopted (internalized) if it is perceived to enhance the individual's knowledge to solve a relevant problem. Informational influence is the process that individuals undergo as they assess the validity of new information (Deutsch and Gerard 1955). The outcome of this process is information adoption, which we investigate at the individual-level, and is defined as the change in attitude and/or behavioral intention resulting from an interpersonal information exchange (Gilly et al. 1998). Unlike most theories applied to managerial problems, the HSM does not predict outcomes per se; that is, both argument quality and heuristic cues can be equally influential on assessments of information validity. Rather than predict how influenced an individual will be by new information, the HSM explains the process of how that individual processes the new information. The balance of systematic and heuristic processing that an individual engages in depends on available cognitive capacity, heuristic cues, and factors that affect motivation to process systematically. Thus, two people may be equally influenced by the same information, but via different cognitive processes. Effects of this may be important in cases where the information is mediated for some of its recipients and not for others. The model developed in this study explains that videoconference participants are more likely to be influenced by available heuristic cues than by the quality of the arguments presented, because videoconferencing increases their cognitive load. The model therefore suggests that heuristic cues may play a greater role in videoconferencing than is currently acknowledged by managers.

3.2. Argument Quality

When an individual systematically analyzes received information, the quality of the arguments embedded in the new information affects information adoption (Chaiken 1980, Petty and Cacioppo 1986a). Thus, consistent with previous dual-process studies, we define argument quality as the factor on which information recipients base their validity assessments during systematic processing. Presented arguments may be well or poorly articulated, resulting in perceptions of them as having higher- or lower-quality argumentation. High-quality arguments induce information adoption when systematically processed, whereas low-quality arguments may inhibit adoption. In laboratory experiments, researchers manipulate the quality of the presented arguments to induce systematic processing (Petty and Cacioppo 1986a). Unfortunately, this cannot be accomplished in field research. Instead, attention to argument quality demonstrates systematic processing.

3.3. Source Likeability

Heuristic processing is activated by cues such as sender and message characteristics (Chaiken 1980). Although there are potentially thousands of cues that inform heuristic processing, dual-process researchers have focused most of their efforts on source likeability (Chaiken 1980, Chaiken and Eagly 1983), source credibility (Sussman and Seigal 2003), source salience (Taylor and Thompson 1982), and message vividness (Taylor and Thompson 1982). This research examines the peripheral cue of source likeability because it is known to be highly influential in other information processing contexts (Chaiken 1979, Eagly et al.

1991). Source likeability is a broad-based cue that encompasses multiple characteristics of an information source. It is defined as the extent to which an information recipient perceives an information source as likeable (Chaiken 1980). People are more receptive to communications that come from likeable sources. Likeable communicators are rated as being more powerful and competent than those rated as less likeable (Chaiken 1979, Eagly et al. 1991).

Most aspects of source likeability are retained when communicating by video; for example, attractiveness and tone of voice are not attenuated by this medium. Therefore, we would not expect to find differences between videoconference and face-to-face participants in terms of the direct influence of likeability on information adoption. However, we would expect to see indirect effects of likeability because VMC increases cognitive workload, as discussed above. Therefore, relative to face-to-face, VMC reduces the amount of cognitive capacity available for systematically processing received information. According to the HSM, heuristic processing takes precedence over systematic processing when available cognitive capacity is limited. Thus, we would expect source likeability to be more influential during VMC than in face-to-face communication. Hence, during assessment of information delivered by a speaker:

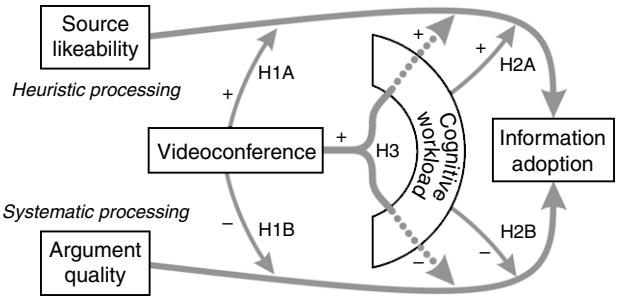
Hypothesis 1A (H1A). *Source likeability will have a stronger effect on information adoption for videoconference participants than for face-to-face participants.*

Hypothesis 1B (H1B). *Perceived argument quality will have a stronger effect on information adoption for face-to-face participants than for videoconference participants.*

As these hypotheses state, the moderating effects of media on likeability and argument quality are in opposing directions. Under conditions of high cognitive workload—as in the VMC context—heuristic processing will dominate systematic processing, and likeability will be more influential on information adoption than argument quality. Conversely, in lower cognitive workload contexts—as in the face-to-face condition—systematic processing will dominate heuristic processing, and argument quality will be more influential on information adoption than likeability. Figure 1 illustrates this situation.

Thus far, we have invoked the dual-process theory to make the case that cognitive workload is the mechanism by which media affects the information processing mode. To assess this, we must determine whether cognitive workload behaves as predicted according to the HSM. We would expect cognitive workload to interact with both likeability and argument quality in opposite directions, mimicking the effects of media, as hypothesized in H1. Therefore, during assessment of information delivered by a speaker:

Figure 1 Videoconference Moderating the Effects of Quality and Likeability



Hypothesis 2A (H2A). *Source likeability will have a stronger effect on information adoption for participants reporting high cognitive workload than for those reporting low cognitive workload.*

Hypothesis 2B (H2B). *Perceived argument quality will have a stronger effect on information adoption for participants reporting low cognitive workload than for those reporting high cognitive workload.*

Moreover, according to our model, it is the higher cognitive workload that videoconferencing demands from its participants that is responsible for the interaction effects of media described in H1. The reason that the media moderates the information adoption process is that it affects the cognitive workload of participants. Therefore, if we account for the moderating effects of cognitive workload, we should no longer see moderating effects of media. Accordingly, during the assessment of information delivered by a speaker:

Hypothesis 3 (H3). *Cognitive workload will mediate the moderating effect of videoconferencing.*

Next, we describe the empirical field study that we used to assess the model and its hypotheses on practicing knowledge workers.

4. Method

The study is a field quasi-experiment in which medical professionals were surveyed as they attended 1 of 19 different live interactive seminars, either face-to-face or via videoconference. These seminars spanned a 12-week period, comprising part of the teaching activities of an urban healthcare consortium. The purpose of the seminars was to teach a method, present research, or describe and discuss a medical technique. Each interactive one-hour seminar was delivered live by a different physician in a large auditorium, followed by questions and answers. These seminars were simultaneously broadcasted via videoconference to a number of smaller sites. Both face-to-face and remote attendees could ask questions. Interactive

video-based seminars are similar to videoconference meetings in that they use the same technology, that is, they both enable distant members to participate, and they both support duplex communication. Interactivity levels vary in both meetings and seminars as a function of many individual, social, contextual, and cultural factors (Weisband et al. 1995). Our setting resembles large meetings and thus is an appropriate way to operationalize our theoretical model.

Attendees were primarily residents, attendings, and local physicians specializing in pediatrics, psychiatry, or orthopedics. Attendance was mandatory for residents but optional for the rest; local physicians received professional credit for their attendance. The seminars took place at either 7:00 or 8:00 A.M. Total attendance levels varied across seminars (from a maximum of 62 face-to-face and 75 via videoconference to a minimum of 14 and 9, respectively). Respondents attended more than one seminar but responded to the survey only once and were specifically asked to refer only to the seminar that they had just attended. Subjects who answered the questionnaire at a videoconference lecture could not have previously attended the same lecture face-to-face because each lecture was unique—presented by a different individual on a different (but possibly related) topic. For this reason no respondents could have attended the same lecture via both face-to-face and videoconference, and we can attribute differences in responses to the media condition. A total of 282 questionnaires were collected, but only 143 (99 by face-to-face and 44 by videoconferencing participants) had valid answers in all indicators used for this research. The disparity in group size was due to the intentional delivery of seminars at the site where most of the audience was physically located.

4.1. Facilities and Procedure

Seminars were delivered face-to-face from one of two (alternating) large auditoriums. From a closed cabin located at the back (or side) of the auditorium, a technician operated the videoconferencing system using professional equipment with several motorized cameras and multiple microphones. Three pairs of integrated services digital network (ISDN) lines were used for full broadcast quality of 30 frames per second. Remote sites used top-quality videoconferencing equipment consisting of two 27-inch monitors and a camera to enable interactivity. There were between two and seven remote sites for any given seminar with at least three participants in each. Up to three remote sites were surveyed at a time. Participation was voluntary, and subjects were blind to the purpose of the study. At the start of each seminar a one-page survey was personally distributed to those who had not previously completed one and was collected at the end of the seminar. The study was described as academic research and anonymity was assured.

Table 3 Measures

Information adoption (three from Bailey and Pearson 1983—attitudinal and two new behavioral)	
How would you evaluate today's grand rounds? (Bailey and Pearson 1983)	Worthless—Valuable Not interesting—Interesting Unhelpful—Helpful
If you had a patient who presents the condition discussed in this grand rounds, would you refer him/her to the speaker?	Never—Most certainly
Has this grand rounds affected the probability that you may contact the speaker in the future?	Not at all—Very much
Cognitive workload (Hart and Staveland 1988)	
How hard was it to follow what the speaker said?	Very easy—Very hard
To what extent did you feel stressed during the presentation?	Low—High
To what extent did you feel distracted during the presentation?	Low—High
Argument quality (Bailey and Pearson 1983)	
Overall, how would you evaluate the information that you received in today's grand rounds?	Incomplete—Complete Inaccurate—Accurate Inconsistent—Consistent Inadequate—Adequate
Source likeability (Chaiken 1979)	
Based on your impressions, how would you rate the speaker of this grand rounds?	Boring—Charismatic Not appealing—Appealing Uninteresting—Interesting Not friendly—Friendly
Involvement (Stamm and Dube 1994)	
How much has the issue discussed in this grand rounds been on your mind lately?	Not at all—A great deal
How interested are you in the topic of this grand rounds?	Not interested—Very interested
How involved are you in the topic of this grand rounds?	Not involved—Very involved

4.2. Instrument Development

All measures (see Table 3) used items from previously validated instruments with the exception of information adoption. Information adoption is conceived of as having both attitudinal and behavioral components (Gilly et al. 1998), as follows: When an individual reports newly received information as being valuable and helpful, he has been influenced toward this positive attitudinal disposition. However, if he is not willing to act on the basis of this new information, its future influence will be limited. For this reason, information adoption also includes a behavioral component that speaks to the degree that the new information motivates intention to act on it. Thus, in accordance with theory, we used a measure that has two subcomponents—one attitudinal and one behavioral. The attitudinal component of adoption utilizes Bailey and Pearson's (1983) information satisfaction measure as has been used in other dual-process studies of media (Sussman and Seigal 2003). Two items

were developed to assess future behavioral intentions of medical practitioners and were combined with the attitudinal items to comprise the full measure of information adoption. To measure cognitive workload we used a modified version of the NASA task load index (TLX), a widely utilized measure of perceived cognitive workload (Hart and Staveland 1988) that has been found to be valid and highly reliable (Rubio et al. 2004). When compared to other subjective workload scales, the TLX has the highest factor validity and is best at representing workload (Hill et al. 1992). To measure argument quality, we used items developed by Bailey and Pearson (1983), and to measure source likeability, we used the previously validated items used by Chaiken (1979). Note that although both source likeability and information adoption have items that use the word "interesting," they are directed toward different foci. The source likeability construct inquires about impressions of the speaker, whereas the information adoption construct asks about the value of the grand rounds themselves, making the constructs theoretically distinct, as empirically evidenced by the factor analysis.

Recipient involvement is a construct that is widely used to investigate the potential dual-process effects of variance in motivation. Participants that are highly involved with the topic are more likely to engage in systematic processing of the new content than those that are less involved (Eagly and Chaiken 1993, Stamm and Dube 1994). We therefore measured participants' perceptions of their involvement in the seminar topic to control for potential dual-process effects, using questions adapted from those used by Stamm and Dube (1994) and adapted by Sussman and Seigal (2003). In prior dual-process studies, involvement, when not manipulated, has tended to be randomly distributed across the sample. However, in the context of field-based knowledge work investigated, levels of involvement were high across the entire sample (avg. = 18.94, std. dev. = 2.49), as was expected, considering the context. Nevertheless, we tested for moderation and did not find involvement to moderate any of the main effects.

The initial questionnaire was pretested in two rounds for representativeness and face validity on 9 IS researchers and 12 physicians. A modified questionnaire was then pilot-tested in four actual seminars using 59 medical professionals, after which a respondent fatigue effect became apparent. Thus, the questionnaire was pruned from 77 to 48 items, based on maximum variance criteria and reliability levels. The resulting composite measures exhibited acceptable psychometric properties. Two versions of the questionnaire were created with the same questions but in a different order, to test for order effects and to help rule out common method bias, as discussed below. Examination of means tests on all constructs and demographics between these two versions revealed no statistically significant order effects.

4.3. Common Method Bias

When all data from respondents comes from a single survey, it is possible that findings could be due to the common method and not to the hypothesized relationships between constructs. Fundamentally, the phenomenon under study is an intrapsychic one, reflecting the inner state of individuals as they process new information. It is therefore inherently challenging to measure, particularly in the field. Also, neither objective argument quality nor a consensus on source likeability are of interest per se because the theory applies to the recipient's perceptions of the argument quality and source likeability. Thus, whereas the use of a single instrument is not ideal, it is a reasonable way to proceed, and its use is not uncommon for field research.

Three statistical tests were undertaken to assess the likelihood of common method bias. First, if common method bias was a problem, respondents would have answered survey questions in such a way as to reflect their own "theory" about the relationships among study constructs. To do this, instead of answering each question independently, respondents would have answered later questions on the basis of how they had answered earlier ones. Individual t-tests for each measure and each construct on the two versions of the questionnaire showed no significant differences between versions. Second, if common method bias was affecting our results, the results of exploratory factor analysis would then not find clean factors. The rotated (varimax) factor analysis found only five factors with initial eigenvalues higher than one, correlations ranging from 0.78 to 0.98, and cross-loadings below 0.30 (see Table 4). Third, we used structural equation modeling to test a measurement model that included common method bias as a construct, and this model did not fit the data ($\chi^2 = 130.67$ d.f. $= 84$ $p = 0.001$, CFI $= 0.89$, and RMSEA $= 0.08$) as well as the five construct model. Furthermore, we were not investigating the direct effects of perceived argument quality and source likeability on information adoption. Direct relationships are susceptible to common method bias because they are relatively easy for respondents to play to. However, our model was based on strong theory about moderating and mediation effects. It is unlikely that respondents would hold a "theory" about the study outcome based on such abstraction. It would also be extremely difficult to answer a series of questions in such a way as to purposefully generate moderation and mediation effects. These respondents were busy medical professionals, making it unlikely that they would expend the additional effort to manipulate a survey.

Table 4 Rotated (Varimax) Principal Component Analysis with Kaiser Normalization

	Factors				
Measure	1	2	3	4	5
Seminar (not interesting—interesting)	**0.825**	0.157	0.209	0.068	0.157
Seminar (worthless—valuable)	**0.778**	0.240	0.185	−0.098	−0.059
Seminar (unhelpful—helpful)	**0.820**	0.105	0.229	0.051	−0.048
Future referrals (never—most certainly)	**0.879**	0.244	0.297	0.005	0.063
Future contact (no—very much)	**0.839**	0.254	0.269	0.002	−0.003
Speaker (boring—charismatic)	0.220	**0.958**	−0.008	−0.008	0.013
Speaker (not appealing—appealing)	0.218	**0.915**	0.042	0.021	0.043
Speaker (uninteresting—interesting)	0.161	**0.941**	0.010	0.015	0.021
Speaker (not friendly—friendly)	0.218	**0.927**	0.004	0.033	0.043
Information (incomplete—complete)	0.217	0.008	**0.948**	0.066	0.029
Information (inaccurate—accurate)	0.264	0.036	**0.885**	−0.012	0.045
Information (inconsistent—consistent)	0.263	0.036	**0.905**	0.053	0.008
Information (inadequate—adequate)	0.275	−0.035	**0.898**	−0.011	−0.042
Follow speaker (easy—hard)	−0.012	−0.008	0.033	**0.986**	−0.058
Feel stressed (low—high)	0.010	0.035	−0.005	**0.970**	−0.044
Feel distracted (low—high)	0.026	0.024	0.052	**0.962**	−0.083
Topic in your mind (no—great deal)	0.050	0.117	−0.018	−0.065	**0.875**
Topic (not interested—very interested)	0.095	−0.087	0.009	−0.103	**0.692**
Topic (not involved—very involved)	−0.099	0.077	0.037	0.014	**0.846**
Rotated eigenvalues	3.89	3.75	3.61	2.88	2.02
Percentage of variance	20.47	19.74	18.97	15.16	10.62
Cumulative percentage of variance	20.47	40.21	59.18	74.34	84.96

Note. Loadings above 0.3 are shown in bold.

4.4. Preliminary Data Analyses

Examination of the skewness and kurtosis of the constructs indicates that they all conformed to standards of normality. Discriminant validity of the constructs was tested by comparing the average variance extracted (AVE) estimates with each of the squares of the correlations (Φ^2) between the constructs. All of the comparisons between constructs passed this stringent test. Convergent validity was tested using reliability analysis and examination of the resultant Cronbach alpha and AVE. As shown in Table 5, all constructs exhibited Cronbach alphas and AVE well above the 0.7, as recommended by Nunnally and Bernstein (1994). To further assess convergent and discriminant validity, we used structural equation modeling to test the measurement model and found an acceptable fit: $\chi^2 = 93.33$ (d.f. = 98) $p = 0.61$, CFI = 1.00, RMSEA = 0.03 (CFI > 0.90 and RMSEA < 0.08 are considered to be a good fit; Browne and Cudeck 1992). Furthermore, a comparison with the null model showed that the null model did not have a good fit and that the proposed model was significantly better ($\Delta\chi^2 = 2{,}109.06$, Δd.f. = 6, $p < 0.001$).

Table 5 Descriptive and Reliability Statistics

	Face-to-face ($n = 99$)		Videoconference ($n = 44$)		Total ($n = 143$)				Cronbach	
Construct	Mean	Std. dev.	Mean	Std. dev.	Min.	Max.	Mean	Std. dev.	alpha	AVE
Media	−1		1		−1	1	−0.38	0.93		
Information adoption	25.16	6.85	24.91	6.72	8	34	25.08	6.79	0.92	0.74
Argument quality	20.12	5.86	20.27	5.24	8	28	20.17	5.66	0.96	0.85
Source likeability	12.84	4.23	13.11	4.22	6	21	12.92	4.21	0.96	0.89
Cognitive workload***	5.37	3.05	12.71	4.47	3	19	7.63	4.90	0.97	0.93
Involvement/ motivation	19.29	2.24	18.13	2.88	12	21	18.94	2.49	0.83	0.86

***Group difference significant at the 0.001 level (two-tailed).

Table 6 Construct Correlations

Construct	Argument quality	Source likeability	Media used	Cognitive workload	Involvement
Information adoption	0.53**	0.43**	−0.16	0.35	0.04
Argument quality		0.09	0.01	0.04	0.02
Source likeability			0.03	0.39	0.09
Media used				0.69**	−0.21
Cognitive workload					−0.11

**Correlation significant at the 0.01 level (two-tailed); $n = 143$.

4.5. Demographics and Descriptive Statistics

Demographic data were collected on gender, age, nationality, domain experience, and hierarchical position. Participants ranged in age from 22 to 80 years, with 80% between the ages of 28 and 68. Their average domain experience was 14 years (52% of the respondents identified themselves as male, and 48% as female; 53% were attending physicians, and 25% were fellows or residents, the remaining 22% were nurses or other medical staff). A comparison of these statistics with those of the general population of medical professionals attending similar seminars showed this sample to be representative.

The largest correlation (0.69) between independent constructs (as shown in Table 6) is between media and cognitive workload (predicted by theory), and it is not enough to cause a multicollinearity problem, as would occur if the correlations were greater than 0.8.

Because this was a field quasi-experiment, we were not able to randomly distribute participants across the two media conditions (face-to-face versus videoconferencing). Thus, we tested for significant differences between them on all demographics and none were found. Furthermore, prior to hypotheses testing, we sought to assess whether participants using videoconferencing would have a higher cognitive workload than those interacting face-to-face, as prior theory suggests and our theoretical model assumes. As shown in Table 5, the mean perceived cognitive workload for those in the face-to-face condition is 5.37, and 12.71 for those in the videoconferencing condition. Hence, videoconferencing is associated with significantly higher perceived cognitive workload than is face-to-face interaction, consistent with theory and prior studies. We can thus proceed to test the hypotheses that rest on this assumption.

4.6. Hypotheses Testing

Hypotheses 1 and 2 investigate moderation effects. None of our potential moderators—media, cognitive workload, and involvement—were significantly associated with information adoption directly (see Table 6). To test for moderation, we used hierarchical multiple regressions (Baron and Kenny 1986) in which the first model includes the independent variables (IVs)—argument quality and source likeability—and the second model adds the interaction terms. This is the most widely used method to test for moderation, and is also the one with the least statistical power (MacKinnon et al. 2002).

As shown in Table 7, Model 1 includes both IVs. Model 2a adds the interaction terms between media and each of the IVs to assess H1A and H1B. Both models and the coefficients for all the constructs are significant, and Model 2a adds significant explanatory power to Model 1 ($\Delta R^2 = 0.09$, $p < 0.01$). The positive beta coefficient for the interaction between media and source likeability indicates that videoconference increases the effect of likeability on information adoption, in support of H1A. The negative beta coefficient for the interaction of media and argument quality indicates that videoconference decreases the effect of argument quality on information adoption, again consistent with theory and supporting H1B. The opposite signs of these beta coefficients indicate that the effects have opposite directions, as predicted by the HSM and hypothesized in H1.

To assess H2A and H2B, Model 2b (shown in Table 7) adds the interaction terms between cognitive workload and each of the IVs. Model 2b and the coefficients for all constructs are significant, and it has higher explanatory power than Model 1 ($\Delta R^2 = 0.12$,

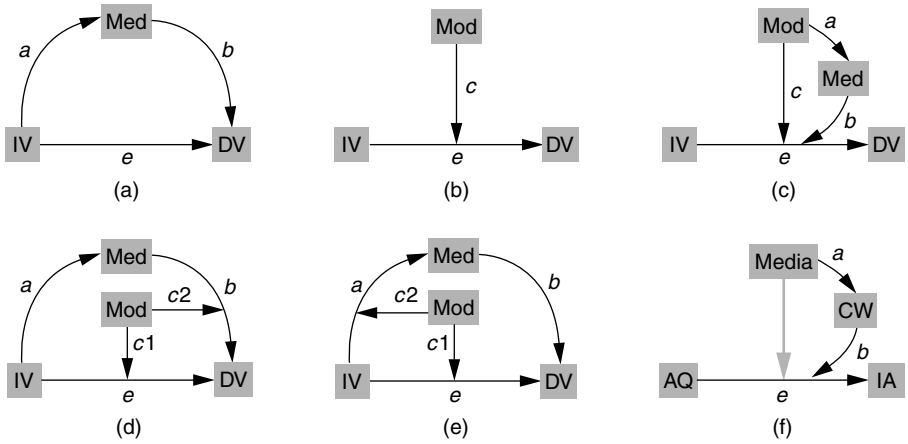
Table 7 Hierarchical Regression Analyses

	Model 1		Model 2a		Model 2b		Model 3	
Independent variable	B	SE	B	SE	B	SE	B	SE
Constant	0.00	0.28	−0.01	0.26	0.01	0.26	0.00	0.26
Argument quality	0.57**	0.08	0.41**	0.08	0.51**	0.07	0.45**	0.08
Source likeability	0.59**	0.10	0.72**	0.10	0.64**	0.09	0.66**	0.10
Argument quality × media			−0.33**	0.08			−0.15	0.12
Source likeability × media			0.31**	0.10			0.07	0.13
Cognitive workload × argument quality					−0.11**	0.02	−0.08*	0.04
Cognitive workload × source likeability					0.14**	0.03	0.12**	0.04

Notes. Model 1: Adj. $R^2 = 0.42$**. Model 2a: Adj. $R^2 = 0.49$**; $\Delta R^2 = 0.09$**. Model 2b: Adj. $R^2 = 0.52$**; $\Delta R^2 = 0.12$**. Model 3: Adj. $R^2 = 0.52$**; $\Delta R^2 = 0.03$**.

*$p < 0.05$, **$p < 0.01$.

Figure 2 **Mediation, Moderation, Mediated Moderation, and Variants**



$p < 0.01$). The positive coefficient for the interaction between cognitive workload and source likeability indicates that cognitive workload increases the effect of likeability on information adoption, supporting H2A. The negative coefficient for cognitive workload times argument quality indicates that cognitive workload decreases the effect of argument quality on information adoption, confirming H2B. Overall then, these hierarchical regressions support H1 and H2, indicating the efficacy of applying the HSM to this field-based context.

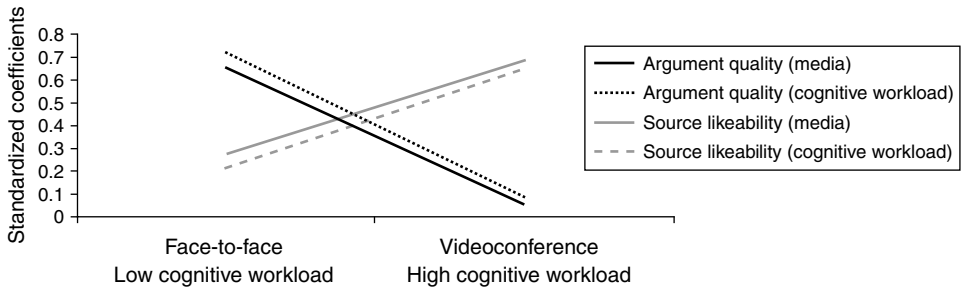
Finally, H3 argues that the above effects of media operates through the mechanism of cognitive workload. We could not perform standard mediation (Figure 2(a)) and moderation (Figure 2(b)) analyses because these analyses pertained to main effects and we were investigating the mediation of a moderation effect (Figure 2(c)). Mediated moderation and moderated mediation, as defined by Baron and Kenny (1986), Muller et al. (2005), and Morgan-Lopez and MacKinnon (2006), refer to direct effects (Figures 2(d) and 2(e)). We were unable to find any published method for our variant (Figures 2(f)) in the literature. For this reason we used a modified version of the test they prescribed.

We have already shown that (1) media affects cognitive workload, (2) neither media nor cognitive workload directly affects information adoption, and (3) both media and cognitive workload independently moderate the effects of argument quality and source likeability on information adoption. Therefore, to show mediation of the moderation effect, Model 3 (Table 7) includes the interaction terms for both media and cognitive workload to test if (a) this adds explanatory power to Model 2, and (b) if all the interaction terms are still significant. The test indicates that Model 3 has higher explanatory power than Model 2a ($p < 0.01$). It also shows that the coefficients for the main effects (argument quality and source likeability) and for both of the cognitive workload interaction terms are significant, while those for both media interaction terms are no longer significant. This indicates that, in the presence of cognitive workload moderation, moderation by media type is no longer a significant effect; thus, cognitive workload moderation mediates the media-moderation effect. Therefore, we can conclude that the interaction effects of cognitive workload absorb the interaction effects of media, in a manner consistent with the HSM and confirming H3.

5. Discussion

Because managerial cognition can play a significant role in processes that affect organizational outcomes (Reger and Palmer 1996), and many organizations do use videoconferencing, it is important to understand how videoconferencing affects cognition. In this study, participants in the videoconference seminars reported being more influenced by how much they liked the speaker than by their assessment of the quality of the arguments presented, whereas those attending the seminar face-to-face reported just the opposite (H1A and H1B). Also, our participants' self-reported cognitive workload was significantly higher for those in the videoconference seminars. These findings are consistent with other cognitive investigations of media use for knowledge work in the field (Sussman and Seigal 2003). The HSM-based model developed predicts no direct effects of media: media affects cognitive workload, which in turn, affects processing mode trade-offs, but these are indirect, moderation effects. Nevertheless, media is not the only factor that could have affected cognitive workload in this research setting. As mentioned above, background noise, interruptions, time pressure, and visual distractions could all have increased cognitive workload. However, we did not observe these factors or the effects of them during data collection, and had

Figure 3 Illustration of the Moderation Effects of Media and Cognitive Workload



no reason to believe that they might have confounded these results.

According to the HSM, it is not the case that more systematic processing leads to greater influence or vice versa—both argument content and heuristic cues can influence outcomes, or not, via either processing mode or combinations of both (Chaiken et al. 1989). For example, a likeable speaker may be more influential to videoconference attendees than to the face-to-face attendees of the same conference, despite the fact that the content delivered to both groups is identical. This example illustrates the potential for managerial conflicts. For instance, if a likeable speaker in contention for a job position made poor-quality arguments, those attending his talk by video might be more disposed to hire him than those attending face-to-face. By splitting the sample at the median of cognitive workload, Figure 3 illustrates this concept and our findings pertaining to H1 and H2.

5.1. A Dual-Process Model of Videoconferencing

On the basis of dual-process theory and our findings, we put forth this lack of main videoconferencing effects as a core component of a dual-process model of videoconferencing. Such a dual-process approach to videoconferencing explains prior IS research studies that have not found significant main-effect outcome differences between VMC and face-to-face communication (Alavi et al. 1995, Crede and Sniezek 2003, Mennecke et al. 2000, Olson and Olson 1997, Suh 1999). However, a minority of IS studies have found main VMC effects (Crede and Sniezek 2003, Jonasson and Kwon 2001, Suh 1999, Sumner and Hostetler 2002). We invoke a core construct of the dual-process paradigm called "need for cognition" to explain these main-effect findings (Cohen 1957), as follows: Need for cognition is a personality variable that measures how much an individual finds systematic processing to be personally satisfying. Because people vary widely in their need for cognition, they are more or less satisfied with a communication experience, depending on how well this need is satisfied. People with high need for cognition tend to be more satisfied with and open to communication that engenders systematic processing rather than heuristic processing (for a review, see Eagly and Chaiken 1993). Findings of media studies in the IS paradigm that have not controlled for this personality variable may have been confounded by it.

Researchers in the communications research paradigm have identified main media effects, finding face-to-face superior to video on two process measures: formality (O'Conaill et al. 1993, Sellen 1995) and outcome efficiency (Anderson et al. 1996, Doherty-Sneddon et al. 1997). The HSM explains why VMC users would experience higher interaction formality because the higher cognitive load of VMC impedes natural interaction patterns. The HSM can also explain differences in efficiency outcomes because heuristic processing is generally faster than systematic processing, and face-to-face communication enables this by providing both more salient social cues for heuristic processing *and* lower cognitive overload.

Hence, a core component of a dual-process model of videoconferencing—lack of main media effects—is actually more nuanced. Findings of prior studies resulting in main effects can be explained by the HSM, because it identifies many factors that affect processing-mode trade-offs. For example, in addition to the communication medium and need for cognition, there are personal relevance, task importance, accountability, fit of content to functional disposition, unexpectedness of content, distraction, repetition, time pressure, knowledge and expertise, direct experience with attitude objects, positive mood, and anxiety (see Eagly and Chaiken 1993, p. 314 for discussion and sources) that have all been found to affect the extent of systematic processing. The videoconference studies discussed above control for few of these factors, and findings may reflect this. The indirect actions of a dual-process approach to understanding VMC can explain contradictory prior findings and, for this reason, offer a plethora of opportunities for future research.

Another important theoretical contribution of this work is the notion that cognitive workload mediates the interaction effects of videoconferencing—H2 and H3. Our statistical analyses support our contention

that cognitive workload is the mechanism underlying the apparently dual-process behavior of videoconferencing. The practical implications of this are such that designers of VMC-based systems should focus on aspects of these systems that reduce cognitive workload. This prescription parallels the goals of recent research initiatives in the area of augmented cognition (Shachtman 2007) in which technical solutions are being sought that will offset the high cognitive processing demands of extremely complex work. At the same time, there may be videoconferencing tasks for which the higher efficiency of heuristic processing is desirable. We see an opportunity to design VMC systems that support highly efficient heuristic processing by making certain informational cues explicit, such as turn-taking or audio location indicators. Both users and designers of VMC systems can benefit from understanding the heightened role of heuristics during videoconferencing that this approach explains.

5.2. Integration with Extant Media Theory

As with social presence and media choice research, our model identifies an invariant property of VMC in the form of greater demand for cognitive capacity. However, such a media-determinant view appears to be at odds with much recent media research identifying emergent and relational aspects of media use (Fulk 1993, Rice and Love 1987, Walther 1992). The HSM-based approach to videoconferencing explains relational VMC effects, as follows. As people interact repeatedly over time, they become familiar with subtle aspects of each others' communication patterns and are better able to structure the communication process (Chidambaram 1996). For example, communicative partners may learn over time to understand each others' turn-taking pauses, pacing gestures, etc. As this happens, the greater cognitive load required to read these cues during VMC tends to decrease, bringing the VMC experience closer to that of face-to-face. In this way, our HSM-based approach is not inconsistent with an emergent relational view of videoconferencing. Nor is it at odds with the social construction paradigm of media use, according to which it is not the media that determines communication patterns but the social patterns surrounding its use over time (Rice and Love 1987, Walther 1992).

A dual-process approach invokes the communication context as an explanation for individual variations in the experience of VMC. Changes in context can affect VMC-based communication in various ways. For example, work distractions such as noise and interruptions can push a communicative interaction away from systematic processing toward heuristic processing by increasing cognitive workload, but if the context of the interaction moves to a quiet place, information processing should become more systematic. Other examples of changes in context that may affect VMC-based communication are organizational incentives that increase the personal relevance of the domain and hence systematic processing, as well as time pressures that increase the need for heuristic processing efficiency. Social influence processes also generate informational cues that inform people about how much cognitive effort they should expend, for example, attending to the arguments of a powerful colleague relative to a weaker one. Or different types of employees may use videoconferencing differently (Webster 1998) based, for example, on their different cognitive capacities or their need for cognition.

Accordingly, one's likelihood of processing new information systematically is affected by a variety of emergent relational and contextual factors that influence one's ability and motivation to do so. Likewise, the accessibility of heuristics and availability of information cues varies over time as the context, interactants, and interaction experience evolves. Because an HSM approach makes room for so many contingencies, it has the potential to integrate aspects of the media-determinant approaches to VMC research with the emergent views that are widely accepted today.

A dual-process view of VMC can also enrich the perspective of social presence (Short et al. 1976) researchers, where they have focused on the cue "filtering out" properties of the new media. For example, these researchers have found that the lack of social status cues online can enable greater participation by peripheral members of online communities (Kiesler and Sproull 1992), and also that the lack of identification cues online enables anonymity and the consequent higher levels of self-absorption. According to this "filtering out" perspective, we should see VMC participants attending more to argument quality, and less to heuristic cues, such as likeability, because likeability cues are less salient under VMC. Interestingly, our findings indicate just the opposite. Participants in the videoconferencing condition were more influenced by their likeability perceptions than by their argument quality ones. This suggests that the extent to which an individual utilizes available cues for heuristic processing depends not only on the salience of the cue, but also on the cognitive effort demanded by the mediated context.

This study is not without its limitations. It relies on single informants and thus is susceptible to common method bias, an issue that we have addressed at length in the methods section. Although a laboratory study would help to clarify this matter, an important contribution of this research is precisely that it took place in the real world of knowledge work, and therefore can be generalized to knowledge workers in organizations. Our sample was comprised

only of medical practitioners, yet we have no reason to believe that these findings are not generalizable to other types of knowledge workers.

6. Conclusion

Cognitive theory is increasingly being used by researchers to investigate the managerial implications of framing, mental models, and sensemaking (Bogner and Barr 2000). Videoconferencing plays an increasingly important role in organizational knowledge adoption and transfer; therefore, it is important to have a clear and basic understanding of its effect on users' cognitive processes. The cognitive theory used—the HSM—is being widely utilized for understanding a multitude of managerial phenomena ranging from healthcare to marketing. This research uses the HSM to understand how knowledge workers process information in the field.

The professionals participating in this study adopted new information regardless of the media used, but they differed significantly in their perceptions of how this process transpired. As discussed above, cognitive capacity is one of the factors that affect trade-offs between systematic and heuristic processing modes. The relatively higher demand for cognitive capacity during videoconferencing decreases the mental resources that would otherwise be available for systematic processing. In this study, these medical professionals reported attending more to the heuristic cue of likeability when they had less cognitive capacity available for systematic processing.

The HSM-based model of videoconferencing we have developed has three core components; first, it explains why main media effects may not be apparent; second, it identifies cognitive workload as the mechanism through which processing differences due to media become manifest; and third, this increases the likelihood that videoconferencing participants will attend to those heuristic cues that are salient. We have long understood that "lean" media, such as e-mail, can filter out certain peripheral cues. This study demonstrates that the relatively "richer" media of videoconferencing doesn't simply approach face-to-face communication—rather, it can change that to which we attend. Hence, certain peripheral cues (such as likeability in this case) are more influential over VMC than in face-to-face contexts.

The robustness of this theoretical framework and the potential weight of its implications underscore the need to pursue this avenue of VMC research. As we increase our understanding of how people process mediated information, both systematically and heuristically, we can design better videoconferencing systems and make better choices regarding when and where to use them.

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