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RESEARCH PAPER

Designing virtual meetings: Reviewing virtual meeting design through the lens of media naturalness

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Abstract

Virtual meetings are here to stay. However, research on the design of these meetings is scarce. To summarize the current state of research on virtual meeting design, we identified 31 studies examining how temporal, physical, procedural, and attendee characteristics affect various within- and post-meeting success factors through media naturalness. Twenty-one of these studies discussed physical design enabling new technological interaction possibilities. Six studies dealt with procedural design and showed opportunities for shaping virtual meetings through structural measures. Four studies related to temporal and three studies to attendee characteristics, which showed further options to influence virtual meetings through time and in-person characteristics. Overall, the effect of virtual meeting design can be complex and opens up a wide field for research and practical applications. Our results are discussed against the background of media naturalness through which we identify the most pressing research directions, questions, and designs to advance knowledge on virtual meetings.

Keywords Virtual meetings · Meeting design · Meeting success factors · Virtual collaboration · Media naturalness

JEL classification M14 · M54 · O33

Introduction

In their role as a means of coordination and collaboration, meetings have become an indispensable part of organizational life. They serve as a central communication outlet, represent organizational culture, and structures; give employees the opportunity to exert influence; and convey the meaning and background of organizational decisions (Allen et al., 2016; Kauffeld & Lehmann-Willenbrock, 2012). Since the 2000 s, the time spent in meetings has risen by 8–10% a year, amounting to a staggering number of 55 million meetings conducted in the USA every single day (Keith, 2015), with each employee spending an average of 6 h in meetings a week (Lehmann Willenbrock et al., 2016b). With the drastic increase in the use of virtual meetings (i.e., meetings utilizing information and communication technology, such as audio- or videoconferencing; Allison et al., 2015; Karl et al., 2022) during the Covid- 19 pandemic, employees were able to maintain effective communication despite geographical separation. For instance, in March 2020, the videoconferencing software Microsoft Teams experienced a 1000% growth in total number of calls (Spataro, 2020), while workers experienced a notable 60% jump of video-based meetings in their daily routine (Reed & Allen, 2021). In the wake of the pandemic, 56% of meetings in Europe and 88% of meetings in North America were either fully virtual or hybrid (Doodle, 2023). This fundamental shift in workplace communication is not just a temporary adaptation but rather a lasting transformation in how organizations operate (Delbosc & Kent, 2024). As companies continue to rely on virtual meetings, the challenge is no longer just ensuring technical functionality but designing meetings that are truly engaging, productive, and effective for participants (Allen & Lehmann-Willenbrock, 2023).

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As a particular form of virtual communication, virtual meetings bear unique challenges that are likely to go beyond issues typically explored in meeting research. A commonly used explanation for the challenges in virtual communication is media interaction being less "natural" than face-to-face interaction in that they convey less non- and paraverbal cues, jeopardizing communication effectiveness and increasing individuals' cognitive load while communicating (see media naturalness theory, e.g., Kock, 2004). These disadvantages have become particularly apparent with the surge of virtual meetings during the Covid- 19 pandemic, resulting in a remarkably high media interest in virtual meeting practices (e.g., Amico, 2021; Anthony et al., 2021; Schwartzberg, 2022). But while many practitioners give advice on the facilitation of successful virtual meetings and new meeting technologies keep emerging, research on how to properly design virtual meetings is still in its early stages. Accordingly, much of what we know about successful meetings does not incorporate the unique challenges posed by the virtual environment. This gap has significant practical implications, as organizations and leaders are increasingly dependent on virtual meetings while simultaneously facing challenges such as declining engagement, communication difficulties, and rising meeting fatigue ("Zoom fatigue") (Karl et al., 2022; Reed & Allen, 2021). Given the rapid and likely sustained rise of remote work and virtual collaboration (Karl et al., 2022; Reed & Allen, 2021), it is thus imperative to understand how virtual meetings differ from traditional, face-to-face meetings and, consequently, which design characteristics we should pay particular attention to when planning and conducting virtual meetings.

Research has shown meeting design, referring to the composition, setting, or conduct of the meeting (Cohen et al., 2011), to be a relevant factor in facilitating successful meetings through increasing meeting quality as well as meeting effectiveness (Leach et al., 2009; Odermatt et al., 2015). Although the research topic of virtual meeting design existed before the pandemic, a larger body of literature on the subject has unsurprisingly emerged since the Covid- 19 outbreak, indicating a plethora of new possible solutions to the challenges posed by virtual meetings. With this review, we aim to contribute to the understanding of virtual meeting design in three key ways. First, we offer a structured overview of meeting design in the virtual context by building on Cohen et al.'s (2011) meeting design model, including physical, procedural, temporal, and attendee design characteristics. Second, we place virtual meeting design in a broader communication framework by exploring its influence on meeting success factors (Lehmann-Willenbrock et al., 2016a), both during (e.g., group dynamics) and after meetings (e.g., satisfaction, individual well-being), using media naturalness theory (Kock, 2004) as a guiding lens. Finally, we identify practical implications as well as new research questions based on our findings to guide practitioners and future research alike to advance the understanding of virtual meetings. Through these contributions, we aim to synthesize existing knowledge, provide actionable insights for practitioners, and support further research in the context of an increasingly digital work environment.

In the remainder of this article, we will first discuss the defining characteristics of virtual meeting design resulting in our guiding review framework. Thereafter, we describe our method and proceed to illustrate the form and effects of virtual meeting design characteristics by summarizing the reviewed studies by meeting design category. In the last step, we will discuss these results against the background of virtual communication and meeting naturalness, derive research directions, and discuss both the practical implications as well as limitations of our review.

Theoretical background

What is a virtual meeting?

First, a meeting can be described as a scheduled gathering of two or more individuals with the purpose of work-related interaction (e.g., Allen & Lehmann-Willenbrock, 2023; Rogelberg et al., 2006). As such, a meeting differs from spontaneous or non-work-related interactions through communication technologies (e.g., informal chat groups). Second, a virtual meeting is a meeting that is not held face-to-face (e.g., Blanchard, 2021; Reed & Allen, 2021). Judging from the emerging stream of research on virtual meetings as well as the vast array of newspaper articles, blog posts, and commercial online meeting applications, virtual meetings are typically conducted through videoconferencing platforms (e.g., Schwartzberg, 2022; Shockley et al., 2021). However, this does not necessarily imply that a virtual meeting is conducted through a video stream. For instance, at the onset of the Covid- 19 pandemic, a maximum of 60% of all Microsoft Teams calls included video (Spataro, 2020). Moreover, especially early research on virtual/technology-mediated communication considers group support systems (GSS; alternatively, group decision support systems, GDSS) as meeting tools which allow interactive exchanges between distributed individuals, even without audio-visual technology (Turoff et al., 1993; Wong & Aiken, 2003). That is, whether in addition to audio- and video streams, or through a separate platform without audio or video functions, virtual meetings may also comprise synchronous text-based interactions.

Accordingly, it appears that a multitude of different technologies that allow for synchronous information exchanges,

from chatting through to video- and audioconferences, can be used to conduct virtual meetings (see Blanchard & McBride, 2020) and new ones – such as virtual reality (VR, e.g., Abdullah et al., 2021; Bohao & Desheng, 2021) – are constantly developing. Even though some scholars and practitioners suggest that meetings can take place asynchronously (e.g., Anson & Munkvold, 2004; Weet, 2020), for the purpose of this review we adopt the common conception of virtual meetings as "different place/same-time" events (see Turoff et al., 1993). Accordingly, we define virtual meetings as *scheduled gatherings between two or more people at different locations for the purpose of synchronous work-related interactions which are mediated through information and communication technologies.* This definition therefore includes chat-based-meetings; audio- and videoconferencing; emerging technologies such as virtual reality as well as a combination of these (e.g., a videoconference with a parallel chat-function); and hybrid meetings (i.e., where co-located and remote meeting participants are connected to each other through information and communication technologies, e.g., Fryatt et al., 2012; Sox et al., 2017).

How do virtual meetings affect work?

To understand the effects of a virtual meeting requires us to understand how technology use influences communication among individuals. Based on theories such as media richness theory (Daft & Lengel, 1986) or social presence theory (Short et al., 1976), communication effectiveness is commonly explained by how well the properties of a communication medium (generally speaking: the type and frequency of cues it can transmit, e.g., nonverbal, such as gestures or facial expressions, or paraverbal, such as intonation or volume) match the informational demands of a given collaborative task. From this perspective, face-to-face interaction is considered to be superior to technology-mediated communication because of its ability to reduce ambiguity and promote interpersonal involvement. The reasons for this are that face-to-face communication has a higher informational value (referred to as *richness*) because it is able to transport verbal, paraverbal, and nonverbal cues, is highly personal, uses natural language, and allows for immediate feedback. Conversely, technology-mediated interactions (such as in the case of virtual meetings) would decrease communication effectiveness because they cannot transport the full range of cues (e.g., no nonverbal cues in the case of audioconferencing, neither nonverbal nor paraverbal cues in the case of synchronous chatting) and feeling of presence that face-to-face communication can.

At the same time, research has shown that individuals are effectively able to compensate for media with lower informational value by adapting their communication behavior (see e.g., channel expansion theory, Carlson & Zmud, 1999; compensatory adaptation theory, Kock, 1998, 2001). Specifically, individuals have been shown to improve both the way they encode (i.e., prepare) as well as decode (i.e., interpret) messages, thereby compensating for the lack of specific cues due to the physical properties of communication media. However, while these compensatory behaviors may help improve communication effectiveness—with (collaborative task) performance differences between face-to-face and virtual teams disappearing over time (e.g., Fuller & Dennis, 2009; Kock, 1998; Simon, 2006; van der Kleij et al., 2009; for meta-analytic evidence, see e.g., De Guinea et al., 2012; Purvanova & Kenda, 2022)—they are associated with substantially higher cognitive demands (e.g., Gajendran et al., 2022; Kock, 2004; Riedl, 2022).

Accordingly, what is helpful for collaborative task performance may not necessarily be optimal for individual well-being (see Kock, 2001). One theory which addresses this area of tension is media naturalness theory (Kock, 2004; for applications to virtual meetings, see Karl et al., 2022; Riedl, 2022). Media naturalness theory takes on an evolutionary perspective and proposes that all individuals should have an innate preference for face-to-face communication (which is most "natural" to them). Communication media's naturalness is thus determined in terms of how they approximate face-to-face interactions, operationalized through the following five criteria: (1) co-location (to what extent people are in the same place); (2) synchronicity (to what extent social stimuli and communicative signals can be transmitted); (3) facial expressions (to what extent facial expressions of participating persons can be perceived); (4) body language (to what extent gestures of participating persons can be perceived); and (5) speech transmission (to what extent speech can be sent and received).

Virtual meetings are thus associated with a lower degree of media naturalness because they cannot transport the full range of naturalness facets (e.g., co-location., facial expressions and body language). Even virtual meetings that enable visual and auditory signal transmission cannot provide a physically shared meeting space (see Nadler, 2020) nor do they enable the exchange of paraverbal and nonverbal cues we are used to from face-to-face interaction (for a detailed overview, see Riedl, 2022). For instance, videoconferences may allow us to see the others' facial expressions, but other body language is less available because of the narrow field of view of a camera compared to a co-located human being (Johnson et al., 2015). Furthermore, videoconferencing cannot mimic a life-size presence in virtual space, or transmit haptic (touch) or olfactory (scent) cues (Karl et al., 2022; Standaert et al., 2016). Moreover, insufficient network resources often lead to considerable delays in cue transmission (Rump & Brandt, 2020).

While these criteria are similar to those underlying ratings of media richness and social presence, a fundamental

difference to media naturalness theory is which effects are considered. Studies that draw on media richness or social presence theory typically analyze how media characteristics impact communication effectiveness. The mechanisms through which these media characteristics are assumed to operate (i.e., reduction of ambiguity, interpersonal involvement) are thus considered in light of how they contribute to collaborative task performance (see Kock, 2001). Media naturalness theory, in turn, concentrates on individual experiences. Specifically, media naturalness theory proposes that increases in media naturalness lead to (1) *reduced information overload* (i.e., cognitive effort associated with processing the communication); (2) *reduced communication ambiguity* (i.e., verbal, non-verbal, and paraverbal behaviors are more difficult to interpret accurately); and (3) *increased physiological arousal* (i.e., less physical excitement evoked by the communication). While the last two are not unlike the mechanisms discussed in media richness or social presence theory, reducing information overload is a mechanism unique to media naturalness theory and may serve to explain why individual perceptions (e.g., effort, depletion, satisfaction, e.g., Gajendran et al., 2022; Kock, 1998; Simon, 2006) often run contrary to collective task performance.

First, media naturalness theory acknowledges that deficits in technology-mediated communication can be overcome with compensatory behaviors (e.g., Bailenson, 2021; Kock, 2001, 2005). For instance, videoconference participants may use exaggerated facial expressions or reaction buttons (e.g., smile, thumbs up) to make sure that others receive the intended message. These behaviors, however, simultaneously increase cognitive effort among interacting individuals (see Kock, 2005, 2009). Similarly, research has shown that the additional adjustments individuals make when reacting to feedback delays (such as those that can occur when signal transmission is impaired to e.g., connectivity issues) are associated with significantly higher cognitive effort (see Dabrowski & Munson, 2011; Kohrs et al., 2016). Second, while media richness theory generally considers higher levels of richness to be better (again, in terms of collaborative outcomes), media naturalness theory would argue that any forms of "enrichment" through hard- or software features that cause media to be less like face-to-face interaction (e.g., augmented reality, virtual reality, mirror effect in videoconferences) would be associated with higher cognitive demands, most likely due to information overload (Kock, 2004). From this perspective, videoconferences are not necessarily better (or may be even worse) than audioconferences, because their additional benefit of offering non-verbal cues for reducing ambiguity may be counteracted by the negative effect that features such as gallery- and self-view options have on information overload (see e.g., Karl et al., 2022; Riedl, 2022).

In sum, the three mechanisms put forward by media naturalness theory (reducing information overload, reducing communication ambiguity, reducing physiological arousal) thus seem to offer the most holistic perspective of how (and why) communication media could impact meeting success at various levels of analysis.

How does meeting design affect virtual meetings?

From a socio-material perspective (e.g., Leonardi, 2012; Orlikowski, 1992; Orlikowski & Scott, 2008), the effects of a technology depend less on the technology's physical properties but more on how these are used in practice. That is, while a technology may provide a structure that constrains how team members interact, team members choose if and how to use these structures (see also adaptive structuration theory, DeSanctis & Poole, 1994). For instance, it is clear that phone calls cannot transmit body language or facial expressions but that does not mean that team members cannot signal important information such as agreement or emotions. Similarly, team members may choose not to use certain features offered by a technology (such as the camera or the chat function) because they see no value in it for the task they are trying to achieve. Accordingly, to understand both within and post-meeting success factors in virtual meetings, we need to turn our attention to *how* virtual meetings are actually conducted. Specifically, we want to focus not on factors that cannot be changed (i.e., a virtual meeting cannot—and should not—be simply replaced by a face-to-face meeting and teams cannot change the nature of their tasks simply because they are harder to achieve virtually) but on those that meeting organizers, facilitators, and/or participants can actively influence.

Although so far mainly evaluated in face-to-face settings, one of those influenceable factors is meeting design, which refers to certain antecedent characteristics related to the composition, setting, or conduct of the meeting and has been identified as an important determinant of meeting success (e.g., Cohen et al., 2011; Odermatt et al., 2015). As meeting design characteristics can be identified and planned either before or at the beginning of the meeting, they may be an important lever to influence the course and results of virtual meetings. For instance, meeting design has been linked to meeting satisfaction, quality, and effectiveness (Cohen et al., 2011; Odermatt et al., 2015). In this review, we draw on Cohen et al.'s (2011) meeting design taxonomy, which distinguishes between four different characteristics of meeting design: physical, procedural, temporal, and attendee characteristics and has since been used on further studies on the subject (e.g., Odermatt et al., 2015). Building on that, these distinct categories offer an empirically established and economic framework to structure and discuss the multifaceted results of our reviewed studies.

Physical characteristics refer to the setting and environment, for example lighting, temperature, or use of meeting space. These can positively affect the meeting atmosphere by creating more comfort and a supportive work environment (Cohen et al., 2011; Leach et al., 2009; Odermatt et al., 2015). In virtual meetings, where participants do not share a physical meeting space, new aspects emerge that are unique to the virtual environment (e.g., the transmission of visual and auditory cues or the virtual meeting modality). *Procedural characteristics* focus on how the meeting is conducted, e.g., the use of an agenda or taking meeting minutes (Cohen et al., 2011; Leach et al., 2009). Well thought out procedural characteristics allow for a structured, task-focused, and goal-oriented meeting. Virtual meetings bring new procedural design aspects into focus, for example new possibilities for visualization and shared task processing. *Temporal characteristics* relate to the use of meeting time and include characteristics like meeting length or the use of breaks. A temporally well-structured meeting allows for more task focus and appears less disruptive (Cohen et al., 2011; Leach et al., 2009). Again, virtual meetings may require a new insights into temporal design. For example, jumping from meeting to meeting can maximize the use of meeting time, yet often fails to deliver sufficient time for recovery in between (Allen et al., 2022). Lastly, *attendee characteristics* refer to features of the meeting attendees (e.g., the number of attendees or meeting facilitation). Odermatt et al. (2015) argue that although every meeting participant should be present for a clear purpose, the selection of attendees is not always based on their relevance to the meeting. Virtual meetings simplify joining meetings without actively contributing, requiring a new consideration of attendee design characteristics.

To analyze the effect of meeting design on success factors in a virtual context, we draw on a framework put forward by Lehmann-Willenbrock et al. (2017). Specifically, we differentiate between within-meeting and post-meeting success factors. The within-meeting factors include group dynamics (e.g., positive atmosphere, turn taking), individual perceptions (e.g., charisma, dominance), and individual reactions (e.g., user attention, concentration). Regarding post-meeting factors, we differentiate between proximal and distal post-meeting success factors. Proximal post-meeting success factors include meeting effectiveness (e.g., quantity and quality of ideas) and satisfaction (e.g., inclusion). Distal post-meeting success factors pertain to individual well-being (e.g., fatigue), performance (e.g., effectiveness), and learning (e.g., knowledge acquisition).

The aim of this review will be to integrate existing taxonomies of meeting design characteristics (Cohen et al., 2011) and meeting success factors (Lehmann-Willenbrock et al., 2017) with the tenets of media naturalness into an overarching theoretical framework that may be used to describe and explain the effects of virtual meeting design. Specifically, we will focus on understanding which virtual meeting design characteristics influence both within-meeting as well as post-meeting success factors and how the three mediating mechanisms proposed by media naturalness theory (reducing information overload, reducing communication ambiguity, and increasing physiological arousal) may explain these effects (see Fig. 1).

Review methodology

Search strategy

We conducted a two-step approach following the guidelines of the JBI Manual for Evidence Synthesis (Peters et al., 2020; see Appendix A), drawing on the methodological framework proposed by Arksey and O'Malley (2005). In a first step, we searched the Scopus database for computer science, engineering, social studies, psychology, business, and multidisciplinary subject areas, looking for articles that contained the following keywords in their title: virtual meeting/videoconference/teleconference/remote meeting*/online meeting*/hybrid meeting*/electronic meeting*/video conferenc* meeting*. We directly excluded non-adult samples as well as clinical studies and studies with a focus on education environments, to ensure that the studies would align with the work-related purpose of virtual meetings. In the second step, in addition to searching in digital databases, we performed a further manual search to find potentially matching articles that did not contain the earlier keywords in their titles and/or abstracts. We searched for further articles in the directories (e.g., on homepages) of relevant journals in case articles were overlooked due to varying forms of data indexing or inaccuracies in our search terms (Hopewell et al., 2007). In order to minimize publication bias, we performed a backward reference check in the retrieved articles and used the function "similar articles" on Google Scholar to find further thematically related and potentially matching papers.

This search strategy generated 880 articles for initial screening. Included are journal articles and conference papers to ensure quality through peer-reviewed contributions. Inclusion criteria included as follows: (1) only empirical research; (2) virtual meetings as per the definition given above; and (3) aspects of meeting design needed to be addressed. Following Cohen and colleagues' (2011) definition, we considered meeting design as aspects that relate to the composition, setting, or conduct of the meeting and which can be "identified, measured, and purposefully planned into a meeting" (p. 91).

Two of the authors double-coded 220 of the articles (i.e., ~ 25%) to ensure a clear understanding of the inclusion criteria. The inter-coder reliability was $\kappa = 0.78$, suggesting a high level of agreement during the initial

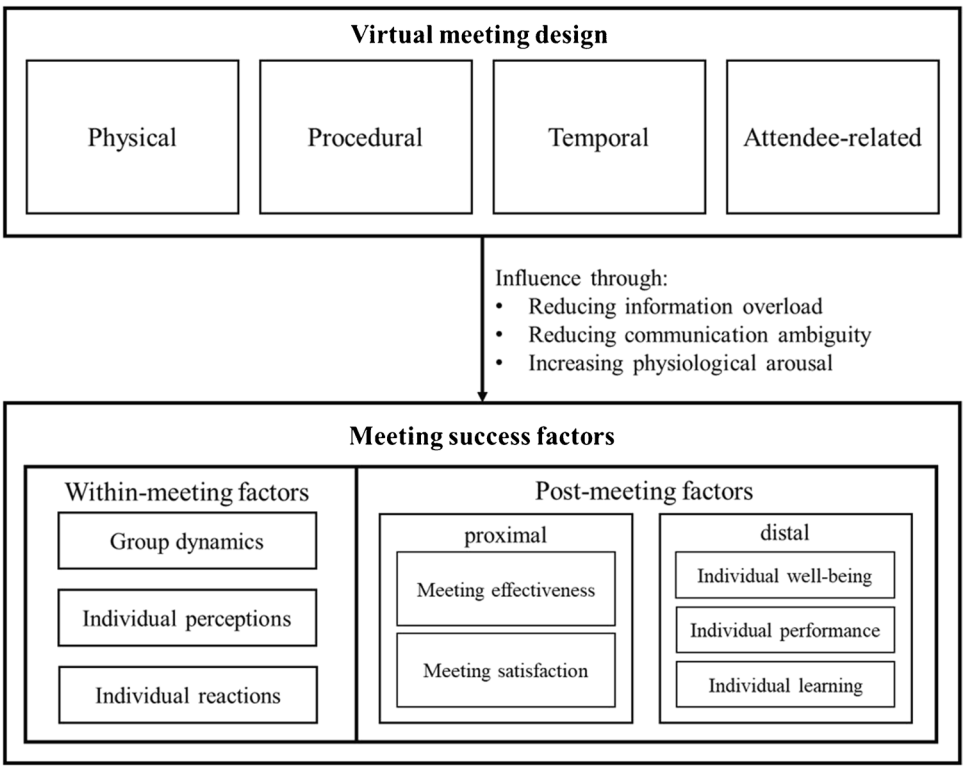

Fig. 1 Review framework based on Cohen et al. (2011), Kock (2009), and Lehmann-Willenbrock et al. (2017)

screening process (values of $0.61 \leq \kappa \leq 0.80$ reflect substantial point-by-point agreement; Landis & Koch, 1977). Cohen's kappa (κ) is a statistic for nominal scales that reflects the level of agreement between coders while accounting for chance agreement (Cohen, 1960). The calculation is based on a contingency table that summarizes how often coders agreed and disagreed on categories (here include versus exclude). From this, the observed agreement is calculated as the proportion of matching decisions (i.e., both coders decided to either include or exclude a study), while the expected agreement due to chance is estimated based on the distribution of category assignments (i.e., based on how often articles were included/excluded). SPSS 28 (IBM Corp., 2021) was used to calculate Cohen's kappa. In addition to the intercoder agreement, the quality of the extracted papers was ensured by only selecting peer-reviewed articles with a sufficient methodological foundation (e.g., in the form of experimental design, conduct of the study or sample representability) and a precise fit with our research objectives and inclusion criteria. This screening yielded 112 articles for detailed inspection. From these, another 81 articles had to be excluded due to two reasons: First, there was a lack of agreement on the definition of virtual meetings. Second, we required meeting design to be varied as an independent variable. In this way, effects of meeting design on the corresponding dependent variables could be isolated. A total of 31 articles emerged from this final inspection.

Sample overview

Our final review sample of 31 studies were published between 2003 and 2023 with almost 70% published after 2020. Thus, a strikingly large proportion of articles were published (and presumably conducted) during the Covid- 19 pandemic (see Fig. 2). Leaning on Gibbs et al. (2017), we classified our studies based on these sample characteristics: journal discipline, data collection (field vs. lab), study design (experimental vs. survey), sample type (organizational vs. student) and cultural context. Table 1 gives an overview of these sample characteristics, while the table in Appendix B lists our studies in more detail.

Results

In the following, we provide a structured overview of the reviewed articles. For each of the four meeting design categories, we describe the results in the following order: First, we explain how the respective meeting design characteristics were operationalized in the reviewed articles. Second, we provide an overall assessment of the impact of meeting design in the reviewed articles following our review framework presented in Figure 1. Third, we describe how the studied meeting design characteristics impacted meeting success in detail, guided by the three mechanisms put forward by media naturalness theory (e.g., Kock, 2004, 2009). That is,

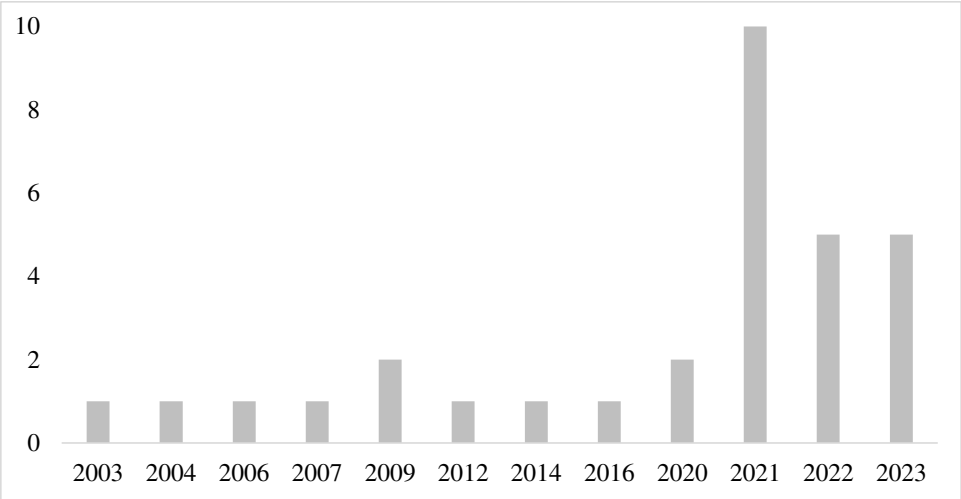

Fig. 2 Publication year of reviewed papers

Table 1 Sample characteristics

Characteristic	Category	% per category
Journal disciplines	Computer Sciences	68%
	Business and Management	16%
	Psychology	10%
	Social Sciences	6%
Data collection	Lab	58%
	Field	42%
Study design	Experimental	71%
	Survey	29%
Sample type	Mixed	39%
	Student	29%
	Employees	32%
Cultural context	European	36%
	North American	32%
	Asian	23%
	Australia/New Zealand	6%
	Cross Cultural	3%

we categorized the reviewed studies based on whether the analyzed meeting design characteristics (1) facilitated the processing of information (e.g., by reducing stimuli in the background of video conference participants; labeled *reducing information overload*); (2) made communication more explicit (e.g., reduction of misunderstandings through live transcription; labeled *reducing communication ambiguity*); or (3) made virtual meetings more immersive (e.g., increasing arousal through the use of virtual reality and avatars; labeled *increasing physiological arousal*). For instance, a study where the respective meeting design characteristic (e.g., individualized icons) was studied in relation to how it would impact interaction dynamics by reducing the potential for misunderstandings (Cho et al., 2021) was categorized as reducing communication ambiguity. The reason for this that reducing communication ambiguity can be considered as the underlying mechanism through which the design characteristic impacted the study's focal indicator(s) of meeting success.

For the purpose of clarity and consistency, the design characteristics in each of the reviewed studies were assigned to only one of the three mechanisms (even though it is possible that characteristics could unfold their effects through multiple mechanisms, such as by simultaneously reducing communication ambiguity but also increasing information overload). Specifically, we categorized characteristics based on the focal indicator(s) of meeting success in the reviewed study, as these were typically tied to different underlying mechanisms. This could mean that the same characteristic was assigned to different categories across different studies, assuming that these studies concentrated on different success factors and underlying mechanisms. For instance, if camera use as a physical characteristic was described in terms of how it impacted within-meeting success factors such as prosocial behavior, it was classified in terms of how it increased physiological arousal in this particular study (Anderle, 2023), yet differently (i.e., in terms of increasing information overload) for a study which concentrated on how camera use impacted post-meeting fatigue (Shockley et al., 2021) or (i.e., in terms of reducing ambiguity) the perception of power (Gruber et al., 2023). Table 2 gives an overview of the reviewed meeting design characteristic, the related media naturalness mechanism, and their influence on meeting success factors.

Physical characteristics

With 21 studies, most papers belonged to the physical design area. Examples of physical characteristics that were studied include camera use (Gruber et al., 2023; Shockley et al., 2021), audio compression (Siegert & Niebuhr, 2021),

Table 2 Overview of results for the influence of meeting design characteristics across the facets of media naturalness on meeting success factors (for a complete overview of the model, see Fig. 1; for an overview on effects, see Appendix B). Effects on meeting success factors are labeled with "+ "= positive; "–" =negative; "0" =no effect; "± "= mixed effects

	Physical		Procedural		Temporal		Attendee	
	Meeting design factors	Meeting success factors	Meeting design factors	Meeting success factors	Meeting design factors	Meeting success factors	Meeting design factors	Meeting success factors
Reducing information overload	• Audio off • Camera use • Self-view • VR-screen background	**Within-meeting** • Individual reactions (+) **Post-meeting** • Individual well-being (-) • Individual performance (+)			• Meeting duration • Meeting frequency • Meeting time	**Within-meeting** • Individual reactions (+)		
Reducing communication ambiguity	• Audio compression • Camera Use • Camera Angle • Field of view • Gaze • Head orientation • Highlighting • Icons • (Non-) revealing display background • Spatial and binaural audio • Uniform display background	**Within-meeting** • Group dynamics (+) • Individual perceptions (+) • Individual reactions (±) **Post-meeting** • Meeting effectiveness (+) • Meeting satisfaction (+)	• Audio visualization tool • Content scheme and scripted collaboration • Real-time transcriptions • Software support system • Structuring acts • Visualization tools	**Within-meeting** • Group dynamics (+) • Individual perception (+) • Individual reactions (+) **Post-meeting** • Meeting effectiveness (+) • Individual performance (+) • Individual learning (+)			• Meeting facilitation • Meeting size	**Within-meeting** • Individual reactions (±) **Post-meeting** • Meeting effectiveness (+) • Individual well-being (-)
Increasing physiological arousal	• Camera use • (Immersive) virtual reality • Malleable mirrors • Mutual gaze • Physical avatar	**Within-meeting** • Individual perceptions (+) • Individual reactions (+) **Post-meeting** • Meeting effectiveness (+) • Individual Performance (+)						

meeting background (Aknuranda et al., 2021; Karabulut et al., 2023), and virtual reality (Abdullah et al., 2021; Tea et al., 2022). Thirteen of the studies were experimental laboratory studies, while the remaining eight were field studies. Overall, findings suggest that physical design elements significantly impact both within-meeting and post-meeting success factors. Specifically, reducing information overload through audio and video settings (e.g., turning off cameras, modifying backgrounds) decreases individual well-being (fatigue, Bennett et al., 2021; Seitz et al., 2022) and improves individual reactions (user attention) and performance (Bohao & Desheng, 2021; Shockley et al., 2021). Reducing communication ambiguity through camera angles, background settings, spatial audio, and visual structuring enhances group dynamics (turn-taking, discourse quality), individual perceptions (charisma, competence, professionalism), and meeting effectiveness (Karabulut et al., 2023; Rosset et al., 2021). Finally, increasing physiological arousal through virtual reality applications, avatars, and gaze simulation strengthens individual reactions and perceptions (engagement, trust, and interaction quality), ultimately leading to better meeting effectiveness (Abdullah, 2021; Tea et al., 2022; Regenbrecht et al., 2014).

Exploring these effects in more depth, several studies have demonstrated how reducing information overload through physical characteristics impacts both within- and post-meeting outcomes. Bennett et al. (2021) found that turning off one's microphone, but not the camera, was associated with lower fatigue levels after virtual meetings. Similarly, Shockley et al. (2021) showed that turning off one's camera was linked to reduced fatigue and increased performance, particularly for women and new team members. The authors suggest that self-presentation demands (i.e., constantly being aware of one's own video feed) create information overload, which turning off the camera helps alleviate. Further supporting this, Seitz et al. (2022) found that self-view contributes to higher cognitive load and self-awareness, with participants experiencing greater fatigue when viewing themselves for extended periods. Finally, Bohao and Desheng (2021) found that blurring meeting backgrounds or highlighting relevant elements increased user attention and concentration.

Concerning reducing ambiguity, studies emphasize the role of visual and auditory modifications and their effects on within-meeting factors (group dynamics, individual perceptions) and post-meeting factors (meeting satisfaction). Gruber et al. (2023) explored the effects of camera angles and found that a higher angle was associated with higher perceived power, whereas a lower angle was linked to lower perceived power, although the overall perception of power seems more complex. Siegert and Niebuhr (2021) found that audio compression negatively affected charisma ratings, particularly for female speakers, suggesting that higher-quality audio improves perceived speaker credibility. Karabulut et al. (2023) examined background transparency, showing that non-revealing backgrounds enhanced perceptions of professionalism and competence, while revealing backgrounds were perceived as warmer and more personal—a preference that varied between employees and customers. Similarly, Bohao and Desheng (2021) demonstrated that highlighting specific elements in the video feed improved individual reactions, as it facilitated faster information processing. Cho et al. (2021) introduced custom icons for emotional expression and found that these reduced misunderstandings and increased turn-taking, fostering better group dynamics. Furthermore, Aknuranda et al. (2021) found that uniform virtual backgrounds (i.e., the same background for all participants) increased meeting satisfaction, likely due to the esthetic appeal and the sense of equality it created. Teoh et al. (2012) found that a wide field of view (i.e., capturing more body language) influenced individual perceptions, while Dacayan et al. (2022) showed that head orientation influenced perceived attention in virtual spaces, enhancing engagement and clarity. In the auditory domain, Rosset et al. (2021) found that spatial audio and visible face cues improved meeting effectiveness by enabling more natural and comprehensible communication. However, Wrigley et al. (2009) found no significant effect of customizable spatial audio settings on meeting success, while Zhong et al. (2022) reported mixed results for binaural audio, which improved comprehension but had inconsistent effects on perceived helpfulness.

Another set of studies examined how physical design elements increase physiological arousal. Anderl (2023) found that camera use was associated with greater prosocial behavior, suggesting that participants with their cameras on were more actively involved in meetings. Similarly, immersive virtual reality (Abdullah, 2021) and multi-user VR applications (Tea et al., 2022) were found to create a greater sense of presence and engagement. Adding to this, Fuady et al. (2016) found that physical avatars in virtual meetings facilitated more engaging interactions, while Grønbæk et al. (2021) demonstrated that malleable mirrors, which simulate a blended interpersonal space, helped remote participants feel included and more physically connected to the discussion. Similarly, Regenbrecht et al. (2014) found that mutual gaze technology, which aligns cameras to simulate eye contact, positively influenced trust, user experience, and inclusion.

Procedural characteristics

We found six articles focusing on procedural design aspects in virtual meetings related to reducing communication ambiguity. In detail, we identified scripted collaboration (Ertl et al., 2006; Kopp & Mandl, 2007), software support

systems (Anson & Munkvold, 2004), structuring acts (Markman, 2009), audio visualization (Marino et al., 2023), real time transcriptions (Son et al., 2023) and visualization tools (Ertl et al., 2006; Kopp & Mandl, 2007). Two studies were conducted in a field setting, the remaining four were laboratory studies. All studies offer possibilities to reduce ambiguity by focusing on means of compensatory adaptation (see Kock, 2001) to increase clarity. Generally, the findings in the reviewed studies suggest that procedural design elements enhance multiple dimensions of meeting success through reducing communication ambiguity. Regarding within-meeting success factors, procedural design characteristics were shown to improve group dynamics by structuring discussions and fostering argumentation quality (Kopp & Mandl, 2007), while also influencing individual reactions such as distraction recovery and perceived emotional awareness (Marino et al., 2023; Son et al., 2023). Effects on post-meeting success include enhanced meeting effectiveness achieved by participation equality and productivity (Anson & Munkvold, 2004) and structured meeting transitions (Markman, 2009). Furthermore, procedural design elements support individual performance and learning, as seen in the effects of real-time transcriptions and visualization tools (Ertl et al., 2006; Son et al., 2023).

In more detail, Kopp and Mandl (2007) examined the combined effects of content schemes (i.e., pre-structured key elements that highlight task-relevant content) and scripted collaboration (i.e., structured sequencing of participant activities). Their findings indicate that these elements significantly improved within-meeting group dynamics by fostering structured argumentation discourse (e.g., increasing confirmation, counterarguments, and justifications). The authors attribute this to the content scheme's ability to highlight critical components of the task solution, thereby reinforcing structured and meaningful discussions. Similarly, Anson and Munkvold (2004) demonstrated that software-supported communication structuring—where participants submit contributions in a virtual tool before discussing them verbally—enhanced meeting effectiveness by promoting participation equality and productivity. Focusing on meeting structure, Markman (2009) found that structuring acts, such as clear opening and closing statements, significantly improved meeting effectiveness. Effective opening and closing sequences help participants orient themselves and reinforce shared understanding, reducing uncertainty and enhancing the flow of the meeting. Ertl et al. (2006) demonstrated that visualization tools—graphical aids designed to guide discussions and illustrate strategies visually—positively impacted individual learning, suggesting that visual structures help participants retain information. In a similar vein, Marino et al. (2023) found that audio visualization, where auditory stimuli are visually represented in the video frame, enhanced perceived emotion recognition in meetings. By increasing environmental awareness, audio visualization compensates for the absence of non-verbal cues, which are often lost in virtual meetings. Lastly, Son et al. (2023) explored the role of real-time transcriptions in sustaining engagement. Their results indicate that transcription features help participants recover from distractions, improving their ability to keep up with the meeting content. Drawing on cognitive evaluation theory (Deci & Ryan, 1985), the authors argue that in virtual settings—where anonymity can limit direct feedback—informational cues (rather than controlling mechanisms) are crucial for maintaining engagement.

Temporal characteristics

We found four articles that dealt with temporal design in virtual meetings (Bennett et al., 2021; Cao et al., 2021; Li et al., 2022; Nesher Shoshan & Wehrt, 2021). Three articles examined the effects of meeting duration in videoconferencing. Moreover, Bennett et al. (2021) and Cao et al. (2021) additionally studied the effect of meeting time (i.e., time of the day the meeting took place), while Li et al. (2022) inspected meeting frequency. All four studies were conducted in a field setting and related to reducing information overload in meetings through shortening the duration and/or the frequency of meetings or by identifying a suitable time frame for meetings. Our findings suggest that temporal design factors primarily influence within-meeting success factors during meetings through reducing information overload. Key elements such as meeting duration, meeting time, and meeting frequency play a role in shaping individual reactions (participant engagement, cognitive load; Cao et al., 2021; Bennett et al., 2021; Nesher Shoshan & Wehrt, 2021; Li et al., 2022). While these factors can positively impact attentiveness and productivity, they may also contribute to increased fatigue.

With regard to meeting duration, neither Bennett et al. (2021) nor Nesher Shoshan and Wehrt (2021) found an effect on fatigue, suggesting that the length of a meeting alone does not necessarily increase cognitive strain. However, Cao et al. (2021) found that longer meetings led to increased multitasking, indicating that as meetings extend, participants are more likely to shift their attention to other tasks. This can be explained by the media naturalness component of reducing information overload—as meetings become longer, the cognitive effort required to sustain engagement rises, prompting individuals to multitask as a way to manage their mental load. Overall, meeting duration primarily affects multitasking (Cao et al., 2021) as an individual reaction, which can impact meeting effectiveness in the long run by reducing participant focus.

Regarding meeting time, Cao et al. (2021) found that early meetings triggered higher levels of multitasking than later meetings. The authors suggest this is due to the daily

work routine, where employees tend to engage in administrative tasks such as answering emails in the morning, leading to divided attention during early meetings. In contrast, Bennett et al. (2021) found that meetings held later in the day led to increased fatigue, likely due to the cumulative attentional demands of prior work events. These findings indicate that meeting timing directly impacts participant focus and energy levels, which in turn affects individual reactions within meetings (fatigue, multitasking).

Concerning meeting frequency, Li et al. (2022) found that higher virtual meeting frequency correlated with greater fatigue, suggesting that frequent meetings accumulate cognitive strain over time, making it harder for participants to remain engaged. This aligns with the principle of reducing information overload, as excessive meetings can lead to mental fatigue and reduced overall individual reactions.

Attendee characteristics

Three of the reviewed articles (Cao et al., 2021; Nesher Shoshan & Wehrt, 2021; Wong & Aiken, 2003) dealt with attendee design in virtual meetings. Both Cao and colleagues (2021) as well as Nesher Shoshan and Wehrt (2021) examined the role of meeting size in virtual meetings, while Wong and Aiken (2003) considered the effect of having a general meeting facilitator present in virtual meetings. Two studies were conducted in a field setting, one in a lab setting. Findings showed that attendee-related design factors influence both within-meeting and post-meeting success factors by reducing communication ambiguity. In terms of within-meeting outcomes, having less participations was shown to have a positive effect on individual reactions (multitasking, Cao et al., 2021). Regarding post-meeting outcomes, well-structured attendee management through the presence of a facilitator improved meeting effectiveness (Wong & Aiken, 2003) but had no effect on individual well-being (Nesher Shoshan & Wehrt, 2021).

With regards to meeting size, Cao et al. (2021) found that meeting size increased multitasking during virtual meetings. Although multitasking may be seen beneficial for some meeting participants (e.g., using the meeting time to get on top of one's emails), this finding suggests that larger meetings lower participants' focus on actual meeting interactions making communication more demanding. In contrast, Nesher Shoshan and Wehrt (2021) found no effect of virtual meeting size on participant fatigue. To explain this finding, the authors speculate on whether meeting participants' subjective perceptions may be more important than objective meeting duration (i.e., perceiving a meeting as long leads to fatigue, not the length of the meeting per se). Regarding the role of a general meeting facilitator, Wong and Aiken (2003) found beneficial effects for both an automated facilitator (i.e., using a facilitation program with two features: (a) encouraging participation and (b) providing important information as well as performing administrative tasks) and an expert-human on meeting effectiveness (i.e., number if unique ideas and unique quality ideas). In contrast, novice-human facilitators were shown to be significantly less effective in facilitating idea generation. The authors argue that expert and automated facilitators minimize errors, whereas novice facilitators often struggle with guiding discussions effectively, negatively impacting both meeting satisfaction and participant performance.

Discussion

General findings

The purpose of this review was to analyze the current state of meeting design research in the virtual context and to uncover the most pressing questions that remain for future research. Therefore, we thoroughly searched the literature on virtual meetings, revealing 31 studies that examined the impact of physical, procedural, temporal, or attendee design aspects on various within-meeting and post-meeting success factors. The findings of our review provide insights into the current state of the virtual meeting design literature, which will stay relevant with the ongoing proliferation of remote work and virtual forms of collaboration. In the following, we discuss the general findings regarding each meeting design characteristic, as well as research directions on how this review may serve to advance future research on virtual meetings. We conclude with the practical implications and limitations of our review.

Most of the reviewed studies examined physical meeting design. Standaert et al. (2021) emphasize a lack of co-location, less available body language, and unobservable facial expressions as weaknesses of virtual communication, especially in videoconferencing. The physical design aspects we identified in our review often targeted exactly these aspects. Operationalizations ranged from visual and auditory factors to complex solutions in the field of hybrid meetings or virtual reality. Many of the studies focused on influencing the type, frequency, and complexity of social cues and making verbal, para-verbal, and nonverbal behavior more feasible in the virtual space (e.g., expanding the field of view to achieve a more naturalistic representation of meeting participants; Teoh et al., 2012, manipulating gaze direction; Regenbrecht et al., 2014, using an avatar or icons, Abdullah et al., 2021 Cho et al., 2021, or affecting audio adaptation; Rosset et al., 2021; Siegert & Niebuhr, 2021). Findings suggest that while within-meeting or proximal post-meeting factors may profit from higher levels of social cue availability, distal post-meeting factors such as individuals' well-being and satisfaction may not (e.g., Bennett et al., 2021; Shockely et al.,

2021). In terms of media naturalness, physical design shows a clear focus on the reduction of communication ambiguity. However, it is striking that it is the only category that offers opportunities to increase physiological arousal. These studies are often oriented towards affect-related outcomes and tend to focus on human factors during the meeting.

Procedural factors appear to be particularly effective in the area of reducing communication ambiguity. Structuring measures as a form of compensatory adaptation (Kock, 2001) offer the possibility of making communication clearer and more unambiguous, which has an effect both during and after the meeting. In this review, we found an overall positive effect on proximal post-meeting factors. This aligns with similar research from the face-to-face domain. For instance, Cohen et al. (2011) and Leach et al. (2009) were able to attribute positive effects to structuring activities (e.g., use of meeting agreement or an agenda) in meetings, particularly as a way to prevent the development of negative behavioral cycles (see Kauffeld, 2007; Kauffeld & Meyers, 2009).

Fewer studies considered temporal design characteristics. In these studies, meeting duration appeared important only for what happened in the meeting (e.g., multitasking, Cao et al., 2021), yet not for post-meeting outcomes. In terms of post-meeting outcomes (here: fatigue), the reviewed studies suggested that when meetings occurred frequently and later during the day, they were associated with higher levels of fatigue (Bennett et al., 2021; Li et al., 2022; Nesher Shoshan & Wehrt, 2021). Temporal factors were mainly related to the reduction of information overload.

Finally, regarding attendee characteristics, we found studies discussing effects on both within-meeting, as well as post-meeting factors. In terms of within-meeting factors, meeting size appeared to increase multitasking behaviors, while it did not impact fatigue as a post-meeting distal outcome (Cao et al., 2021; Nesher Shoshan & Wehrt, 2021). In terms of proximal post-meeting outcomes, Wong and Aiken (2003) found a positive effect of a skilled (either automated or expert human) compared to a novice facilitator on meeting effectiveness. This aligns with findings from traditional meeting research that the role of a facilitator does not necessarily have a positive impact in a discussion (Lehmann-Willenbrock et al., 2016b), but the appropriateness of how it is conducted does matter. Similar to procedural factors, attendee factors focus on reducing ambiguity. While the articles mainly looked at proximal post-meeting factors, a focus on perceptions during the meeting seems to play a role here as well.

Emerging research directions

The results of our review point to a range of emerging research questions warranting further investigation, which can be subsumed under two core research directions (see also Table 3). First, the surge of research on virtual meetings conducted as a result of the Covid- 19 pandemic (e.g., Bailenson, 2021; Karl et al., 2022; Riedl, 2022; Shockley et al., 2021) has uncovered a *controversy between achieving collective goals versus promoting individual interest*. The findings of our review also reflect this tension: while design choices aimed at reducing communication ambiguity often enhance within-meeting and proximal post-meeting success factors related to group functioning, they can also impose higher cognitive strain on individuals. A large portion of reviewed studies manipulated physical design characteristics to improve the transmission of facial expressions, body language, and speech (e.g., by enlarging the field of view or optimizing audio transmission; Rosset et al., 2021; Teoh et al., 2012). While these enhancements generally facilitated

Table 3 Exemplary research questions and design for proposed research directions

RD1: How can virtual meeting design resolve the tension between individual interests (e.g., lower cognitive strain) and collective goals (e.g., meeting effectiveness)?
• Which areas of conflict arise in virtual meetings between individual and group?
• How do areas of conflict influence individual and group factors in virtual meetings?
• How can effects on individual and groups be collectively integrated to ensure a positive effect on both instances?
• What recommendations for action at individual and group level can be drawn from virtual meeting design?
RD2: How do different meeting design characteristics interact to influence within- and post-meeting outcomes?
• How do virtual meeting design characteristics interact with each other?
• How can virtual meeting characteristics be used to compensate for shortcomings in other characteristics?
• How can the interaction of design characteristics be used to enhance the positive effects of meeting design?
• How do new digitization-related features (e.g., augmented or virtual reality, artificial intelligence) influence the interaction between design characteristics?
• In further research in this area, the research design in particular should be taken into account. The following approaches could be considered:
• Experimental simulation designs
• Field studies with "real" work teams
• Objective recordings of meeting design and meeting success factors (e.g., eye tracking)
• Longitudinal designs for researching long-term effects
• Intervention studies to actively shape meeting design
• Multilevel analyses to examine individual and team factors simultaneously

within-meeting communication and group effectiveness, they also increased cognitive strain and fatigue for individuals—particularly through features like camera and microphone use in videoconferencing (Bennett et al., 2021; Nesher Shoshan & Wehrt, 2021; Shockley et al., 2021). A similar paradox arises in procedural meeting design, where supplemental features such as visualizations reduce ambiguity (Ertl et al., 2006), but may simultaneously increase information overload as participants must devote additional cognitive resources to processing them. These seemingly contradictory findings can be explained through media naturalness theory: while a lack of naturalness in virtual communication can be compensated for by increasing social and situational cues, an overload of such cues may create excessive cognitive demands (see compensatory adaptation, Kock, 1998; channel expansion, Carlson & Zmud, 1999). These contradictions underscore the need for virtual meeting design to act as a mediator between individual interests and collective goals. Instead of forcing a binary decision between cognitive ease and communicative effectiveness, meeting design could offer adaptive solutions that dynamically balance these conflicting needs. This leads to the following key research direction:

RD1: How can virtual meeting design resolve the tension between individual interests (e.g., lower cognitive strain) and collective goals (e.g., meeting effectiveness)?

Second, beyond balancing individual and group needs, our review suggests that *virtual meeting design characteristics do not operate in isolation but interact dynamically*, shaping meeting success in complex ways. A deeper understanding of these interactions between design elements is essential to resolving the tensions between communication ambiguity and information overload. One key insight is that the quality and type of visual and audio cues—rather than their sheer quantity—determine their effectiveness. For instance, camera use in videoconferences can be problematic due to excessive focus on the speaker's face and the "mirror effect" of self-view, which increases cognitive load (Riedl, 2022; Seitz et al., 2022; Shockley et al., 2021). However, our review also identifies potential solutions that allow for a more natural capture of interactions, such as enlarging the field of view and integrating spatial audio (Rosset et al., 2021; Teoh et al., 2012). Similarly, procedural design characteristics that enhance meeting structure—such as content schemes, structured collaboration, or real-time transcriptions—may help mitigate both communication ambiguity and information overload (Kopp & Mandl, 2007; Markman, 2009; Anson & Munkvold, 2004).

The interconnected nature of meeting design becomes particularly evident when considering real-world applications. Meetings are often the result of unconscious design choices, without anticipating how different design elements interact. Consider the following example (exaggerated for clarity): A meeting is scheduled in the late afternoon to reduce multitasking (temporal design; Bennett et al., 2021; Cao et al., 2021). Cameras are turned on to support social interaction, but self-view remains optional (physical design; Seitz et al., 2022). Since the meeting involves a large number of participants, an agenda and real-time transcription are provided to enhance comprehension (procedural design; Ertl et al., 2006; Son et al., 2023). Two leaders serve as facilitators to support engagement (attendee design; Wong & Aiken, 2003). In this scenario, design elements reinforce, compensate for, or even counteract one another. For instance, camera activation can increase cognitive load, but real-time transcription may offset this by making information more readily available. Likewise, social cues (e.g., camera use, facial expressions; Cho et al., 2021) can enhance communication, while visualization tools (Ertl et al., 2006) can initiate new cognitive processes, and temporal design can hinder distraction through multitasking (Cao et al., 2021).

In sum, virtual meeting design is not simply about implementing isolated best practices but rather about orchestrating a system of interdependent elements. Conceptually, this aligns with job crafting theory (Slemp & Vella-Brodrick, 2013), wherein individuals actively shape their work environment to compensate for known weaknesses and enhance strengths in virtual collaboration. This leads to the following research direction:

RD2: How do different meeting design characteristics interact to influence within- and post-meeting outcomes?

In general, the results of our review reveal that while prior research has largely centered on physical design characteristics, other design perspectives integrating the other meeting design factors are needed. Beyond reducing communication ambiguity, future studies should address information overload and explore mechanisms for increasing physiological arousal to sustain engagement and cognitive performance. Following Lehmann-Willenbrock and Allen (2018), diverse methodological approaches are needed. Experimental simulation designs can help isolate causal effects of meeting structures, while field studies with real work teams ensure ecological validity. Objective measures, such as eye tracking (e.g., Seitz et al., 2024) or behavioral coding (e.g., Kauffeld & Lehmann-Willenbrock, 2012), offer deeper insights into attention dynamics and cognitive load, and longitudinal studies are crucial for assessing the long-term impact of meeting design on success factors. Intervention studies can further refine best practices, while multilevel analyses are important to understanding how individual and team-level factors interact in virtual meeting settings. Building on these directions, future research must move beyond isolated design

elements and adopt a more integrative perspective—one that not only considers structural and communicative aspects but also their dynamic interplay in shaping effective meetings.

Practical implications

Regarding the application in practice, a range of implications for virtual meeting practice can be drawn on the results of our review. Concerning physical design characteristics, enhancing social cue conveyance can improve user experience and engagement. This can be achieved through hardware solutions (e.g., headsets for spatial audio, Rosset et al., 2021; Wrigley et al., 2009) and software customizations (e.g., adaptive meeting backgrounds, Aknuranda et al., 2021; virtual reality highlights, Bohao & Desheng, 2021; camera angle adjustments, Gruber et al., 2023). These features can increase user attention, trust, and overall meeting effectiveness by reducing communication ambiguity and reinforcing social presence (Cho et al., 2021; Shockley et al., 2021). However, cognitive demands must be carefully balanced. While additional cues help reduce ambiguity, an overload of stimuli can contribute to fatigue and cognitive strain (Bennett et al., 2021; Seitz et al., 2022). The right number and type of cues may further depend on meeting type. For example, hybrid meetings may have different requirements than video or audio-only meetings, and long-term collaboration may naturally compensate for reduced visual cues over time (Carlson & Zmud, 1999). Additionally, participant characteristics should be considered. Certain groups, such as women and new team members, may require additional support to ensure equal participation and visibility (Shockley et al., 2021; Siegert & Niebuhr, 2021). Moreover, features like gaze adjustment, user-controlled display settings, and speaker identification tools can help mitigate communication challenges and improve inclusivity (Grønbæk et al., 2021; Abdullah et al., 2021).

Building on that, our findings emphasize the importance of structured procedural design in virtual meetings, reinforcing prior research on the need for clear frameworks in virtual collaboration (Handke et al., 2020; Marlow et al., 2017). Specifically, visualization tools, structured content schemes, and scripted collaboration can enhance meeting dynamics by improving argumentation discourse, task solutions, and overall group coordination (Anson & Munkvold, 2004; Ertl et al., 2006; Kopp & Mandl, 2007). Moreover, real-time transcriptions and audio visualization tools can aid individual perception, helping participants process discussions more effectively and enhancing perceived emotional expression (Marino et al., 2023; Son et al., 2023). Procedural structuring, such as agenda setting and clearly defined opening and closing sequences, also supports participation equality and meeting effectiveness, ensuring a smoother transition between different meeting phases (Markman, 2009). Finally, structured software-supported systems and meeting facilitation tools can mitigate the impact of reduced media naturalness. When cameras are turned off to reduce fatigue, well-structured meetings can sustain engagement and coordination by compensating for the absence of social cues (Son et al., 2023). By integrating these structured elements, virtual meetings can achieve higher levels of participation, collaboration, and individual learning outcomes.

From a temporal perspective, meeting duration, time of day, and frequency did not directly determine meeting success but were linked to individual well-being and fatigue (Bennett et al., 2021; Cao et al., 2021; Li et al., 2022). Specifically, meeting timing and frequency should be carefully managed, as they influence fatigue levels, which can either remain neutral (Nesher Shoshan & Wehrt, 2021) or increase depending on meeting conditions (Bennett et al., 2021; Li et al., 2022). Our findings on attendee characteristics reinforce prior research on meeting facilitation, showing that structured facilitation—whether human or automated—can improve meeting success by increasing perceived effectiveness and group cohesiveness (Wong & Aiken, 2003). While meeting size did not show a direct impact on virtual meeting outcomes, it remains a relevant factor in shaping individual reactions and engagement levels (Cao et al., 2021; Nesher Shoshan & Wehrt, 2021). Additionally, multitasking in virtual meetings presents a nuanced challenge. While it can enhance individual productivity, it may also reduce overall meeting effectiveness by diverting attention from group cohesion and discussion quality (Cao et al., 2021). Organizations should carefully evaluate whether multitasking should be encouraged or minimized based on meeting objectives. Generally, meeting design should be adapted to participants' needs and organizational conditions to balance well-being, engagement, and effectiveness in virtual collaboration.

Limitations

Although this review has attempted to provide as comprehensive and holistic an insight into virtual meeting design as possible, some limitations in terms of substance are to be expected. First, the study landscape in the area of virtual meetings is not optimal. While a comprehensive literature base on virtual collaboration already exists, the situation on meetings and especially meeting design is not yet at a comparable point. Accordingly, much of the literature reviewed in this review emerged in the context of the Covid pandemic-induced digitalization surge and increased use of virtual meetings. As a result, our review serves primarily as an overview paper that will advance further research in this area in a more focused way. Second, concerning our methodological approach, our inclusion criteria directly exclude some studies from the review that include opportunities for meeting design but do not embed them in a broader context

(e.g., effects on outcomes). Our review aims to take a holistic view of meeting design. Thus, the influence of design on the participating subjects is essential, which has led to a smaller number of final studies. This drawback in quantity was compensated in this review by the possibility of developing a potential effect model. In addition, this study is methodologically limited by the fact that it focused primarily on the findings from one database as well as manual search. While Scopus provides a comprehensive range of publications, it inherently limits the scope of this review by excluding potentially relevant studies indexed in other databases such as Web of Science, IEEE Xplore, or Google Scholar. In addition, this study was supplemented by a manual search, which, while valuable, does not fully compensate for this constraint. Depending on access, it would be interesting for future research to cross-check potential findings with our perspective. Third, in order to ensure a sufficiently large study base, a broad spectrum of virtual communication forms (including chat systems, video conferencing, or virtual reality) were represented in this review. While this provides a deeper insight into the multifaceted nature of virtual communication, it limits the generalizability of the results.

Conclusion

In conclusion, virtual meetings have become an essential part of modern organizational practices, making intentional and evidence-based design choices essential for maintaining productivity, engagement, and collaboration. With this review, we wanted to (1) present an overview of the current state of virtual meeting design research, (2) integrate virtual meeting design into a broader framework including meeting success factors as well as a focus on media naturalness, and (3) derive scientifically based implications for both research and workplace application. Summarizing, this review offers a structured synthesis of research on virtual meeting design, grounded in Cohen et al.'s (2011) meeting design model. By examining physical, procedural, temporal, and attendee characteristics, we highlight how these design elements shape the challenges and opportunities of virtual meetings. Using media naturalness theory (Kock, 2004), we connect these elements to broader communication dynamics, showing their influence on both in-meeting processes and post-meeting outcomes. Our findings emphasize that effective virtual meeting design is not a one-size-fits-all solution but must be adapted to specific organizational needs, meeting objectives, and participant dynamics. Successfully designed virtual meetings require balancing competing demands, such as managing individual cognitive load while supporting team collaboration. Practical improvements, such as optimizing information flow, integrating non-verbal cues, and structuring meetings for both efficiency and inclusivity, can significantly enhance virtual meeting effectiveness. This calls for a flexible and reflective approach to meeting design, tailored to the goals and circumstances of each situation. Beyond offering practical guidance, we identified key areas for future research, including how virtual meeting design can address tensions between individual interests and collective goals, how different design characteristics interact to influence meeting outcomes, and how virtual meeting design evolves over time to shape future meetings. By continuing to explore these dynamics, researchers and practitioners alike can contribute to developing virtual meeting environments that are not only functional but also engaging, adaptive, and impactful.

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