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The Relationship of Collaboration Technologies and Cognition and Affect

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Abstract

Collaboration technologies (CT) are integral for today's workplaces and the use of CT impacts human brain and behavior. The consequences on cognition and affect of CT users have been empirically investigated since the 1970s. However, the research landscape is scattered and a comprehensive overview is missing. Consequently, we systematically analyze research about the relationship of CT and cognitive and affective user states and processes through an advanced systematic literature review based on the conceptual foundation of the time-space matrix, the stimulus-organism-response paradigm, and the workplace outcomes framework. Our results show an increase in remote CT, alongside a focus on individual analysis and affective constructs, while group level studies concentrate relatively stronger on collocated scenarios. We contribute with avenues for future research like the underrepresentation of group level analysis, a need for unified conceptualization and understanding of cognitive and affective constructs in theory and for deriving design knowledge to create advanced, cognition- and affect-sensitive CT features.

1. Introduction

Collaboration has become essential for organizations [1]. By now, it takes on average more than 80 percent of the work time of employees and keeps growing enabled by collaboration technologies (CT) like groupware, instant messaging, or video conferencing [2]. The consequences of the COVID-19 pandemic have accelerated this trend of CT importance even more, for example leading to an all-encompassing exhaustive shift to remote work since the crisis hit in in 2020, and to 62% of employees in home office in US companies [3, 4]. In summary, it is evident that CT are an integral part of work life and, at the same time, with a glance to the new normal, represent a fundamental basis for future forms of remote and presence work.

However, the intensive use of CT also imposes major challenges. While technology usage encompasses certain impediments [5], CT further causes interpersonal interactions implying challenges for the human brain and human behavior. The Harvard Business Review even circumscribes these with a "Collaborative Overload" [2]. For example, the remote character of CT implies a leaner communication which does not permit transferring as much information as in face-to-face interactions [6], a field which was targeted by media richness literature. Such aspects make collaboration via CT significantly more difficult and show the complexity of CT development.

In order to mitigate upcoming challenges, the consequences of CT on individuals and groups of individuals at work have been intensively investigated since the early 1970s (cf. [7] with a research agenda for the information systems (IS) domain) and continue to be of focal interest today (e.g. [8, 9]). Initially, while decision-making aspects and cognitive facets were in the main focus of research, like the design of decision rooms (e.g. [10]) and group support systems (GSS) (e.g. [11]), more advanced states like motivation or affect have become prevalent in CT research recently (e.g. [8, 12]). However, results in research and practice about consequences of CT and its usage, for example in remote work, are diverging. Depending on the distinct technology, findings suggests that CT increase productivity [13], engagement [14], or team effectiveness, while on the other hand they also report negative impact on well-being [15] or mental workload [16]. Thus, existing research findings on the effects of CT on user states like cognition and affect is scattered and an integrated view does not exist. In order to close this research gap, our work is investigating extant knowledge about CT and the interplay with cognitive and affective user states on the individual and group level. Therefore, our work is

aiming to answer the following research question (RQ): *"What do we know about the relationship between CT and cognitive and affective user states of individuals and groups?"*

In order to answer this RQ, we conduct an advanced systematic literature review (SLR) [17]. To capture relevant knowledge, we broaden our search strategy beyond the IS community and include the domain of computer-supported cooperative work (CSCW) into our search process. In this paper, we provide an overview of the key pillars of this study, CT and user states and processes, cumulating in a framework of analysis built on the time-space matrix of CT [18], the stimulus-organism-response (S-O-R) model [19], and the workplace outcomes framework [20]. The result of our synopsis provides an overview of the empirically grounded relationship of CT and user states and processes. Based on extant knowledge, we allocate the reviewed publications into respective dimensions. Overall, our review identifies an increase in remote CT with individual level focus, in contrast to early research on meeting rooms or collocated group decision scenarios [21]. This comes along a focus on affect since 2000 in contrast to previous decades characterized by a stronger cognitive focus (e.g. [22]). However, group level research remains applied on collocated scenarios while individual level research investigates remote collaboration.

In summary, we intend to contribute to research with a framework for analyzing the relationship of CT with user states and processes, and by pointing towards future research avenues like the underrepresentation of group level research, the need for an unified understanding and conceptualization of affective and cognitive constructs in theory, and the derivation of design knowledge for CT features which are sensitive regarding cognition and affect towards more efficient and meaningful collaboration in future workplaces.

2. Conceptual foundations

Collaboration technology

CT is conceptualized as technology designed to assist two or more people to work together at the same place and time or at different places and/or different times [23, 24]. The evolution of this research stream has comprised multiple sub-fields. Starting with group decision support systems (GDSS) and computer-supported cooperative work (CSCW), over the terms GSS, or groupware, they have been finally comprised under the umbrella term of CT [23, 25]. Functionally, CT is a combination of information technology hardware and software which provides different affordances to its users: (1) support for communication between partners, such as digital communication to augment or replace analogue communication, (2) information-processing support, such as modeling or voting, and (3) support to help participants adopt and use the technology, such as agenda or calendar tools [23, 26, 27]. [26] provide a comprehensive summary of CT starting in the 1970s and describe illustrative the emergence of this research stream around decision environments like meeting rooms. Recently, empirical research has drawn attention to holistic collaboration platforms in organizations and key functionalities of collaboration engineering (CE) [28, 29], as well as to effects on virtual team states and processes through remote work technologies [30]. However, there exists little knowledge on how CT impacts human user states and processes.

Several taxonomies have been proposed to classify CT. The time-space matrix by [18] is, however, still the most commonly used one [31] (see Figure 4). It divides technologies according to their spatial application and their temporal sequence. The result is a matrix with four quadrants: *(1) Asynchronous and collocated* describes CT like local meeting boards*, (2) Asynchronous and remote* contains e-mails and blogs*, (3) Synchronous and collocated* describes meeting rooms and support system for group facilitation at the same place, and *(4) Synchronous and remote* consists of instant-messaging or video-conferencing. The advantage of this classification is its simplicity. We apply this taxonomy due to this simplicity and applicability for allocating existing CT in our paper. Therefore, the CTs identified will be assigned to the four quadrants.

After 2000, the Web 2.0 with the domain of social computing, also called social media, emerged [32]. In contrast to existing CT it contains different characteristics as for instance large and open communities with user-generated content [25]. Social media technologies (SMT) have many different use-cases as they can support search, file exchange, or instant communication at the same time [33]. These advantages have also been leveraged by companies, leading to enterprise social networks or social media [34]. These SMT provide opportunities for new forms of collaboration: "[..] the communication or broadcasting of messages to coworkers in the organization; to signal specific coworkers as communication partners, to edit and distribute files, and view all sorts of content (messages, connections, text, and files) edited by others in the organization at any time." ([35], p.2). However, a conceptual

examination of research focusing on SMT and its impact on user states and processes remains scarce.

Cognitive and affective states and processes

Interacting with CT triggers certain outcomes. This idea follows the S-O-R paradigm that posits that environmental cues act as stimuli that influence an individual's reactions which in turn influence behavior [19, 36]. These reactions are not unidimensional but involve the processing categories cognition and affect. Research has focused for a long time on cognition as a rationale, information-processing core of the human brain. However, "cognitive processing of a stimulus cannot operate independently of affective factors" ([8], p.2). Therefore, the long-lasting focus on mere cognitive constructs, like decision making for groupware outlined by [7], has changed towards a broader scope of cognitive, affective, and behavioral user reactions, processes, and states (cf. [20]). However, the interplay between these reactive states and processes is manifold and has not yet been clearly elaborated in contemporary research [36]. In order to clearly separate these reactions, we subsequently define the key concepts.

Cognition. Cognition is defined "[..] as the activity of knowing: the acquisition, organization and use of knowledge. It entails both knowledge structures (organization) and processes (acquisition and use) that occur within a given (human) cognitive architecture." ([37], p.2). Thereby, it is connoted with the processing of information [20]. Some sources further separate attention and the perception of stimuli from cognition, since it is the entry point, and thereby the foundation, for the S-O-R paradigm. In general, however, it is classified as cognition by its nature of cognitive information processing [38].

Affect. Affect is the result of evaluative reactions to observed stimuli that serve to catalyze behavior [39]. "It is a neurophysiological state consciously accessible as a non-reflective feeling that is an integral blend of hedonic value (pleasure–displeasure) and activation value (activated-sleepy). Affect is an umbrella term that represents a set of concepts that differ greatly from one another [40]", including emotions, mood, and temperament ([36], p.3).

Finally, such user states and processes describe intra-personal processes that remain typically on the individual level. However, when individuals interact, groups evolve [41]. Research describes group formation and interaction processes with different models, such as the Input-Process-Output model [42]. Within these models, emergent states and processes develop which are highly interdependent. These states and processes reflect the previously outlined states from the individual, e.g. cognition and affect, to the group level, e.g. shared mental models or cohesion [43, 44]. These states and processes cover the processing categories of cognitive and affective user states. Therefore, we use these states as core categories for our review.

Framework of analysis

Based on these conceptual foundations, we apply the S-O-R paradigm [19] and the workplace outcomes framework [20] on top of the time-space matrix of CT [18, 45] in order to put these constructs into a relationship. Additionally, we aggregate publications about SMT in a dedicated category. The S-O-R paradigm posits that environmental cues act as stimuli that influence an individual's cognitive and affective reactions, which in turn influence behavior [19]. The workplace outcomes framework represents a collection of outcomes relevant to the workplace postulated by [20]**.** Workplace outcomes can be summarized as performance or task-related outcomes as well as social or non-task-related outcomes like social relationships and well-being. In summary, we derive a framework of analysis for our SLR. In this analysis framework, we investigate the connection in empirical research on CT and SMT between the technology, user states and processes, and outcomes. Complementing the S-O-R model, we posit CT and SMT with their subdimensions as stimuli. The user states and processes are classified into the two major dimensions of cognition and affect and represent the inner processes of the organism (individual or group). Finally, cognitive and affective states and processes lead to a response of the organism to the respective stimulus following the S-O-R paradigm which influences different outcomes. These outcomes are categorized into task-related and social/non-task-related outcomes (see Figure 1).

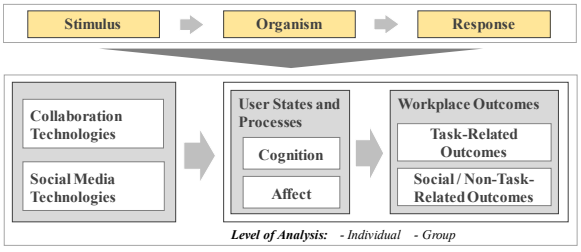

Figure 1. S-O-R paradigm and framework of analysis.

3. Research methodology

In order to answer the research question, we conducted an advanced SLR following the approach

of [17] with an expanded search strategy leading to additional relevant results. According to the guidelines, a SLR is divided into three phases. First, we developed the review protocol. In detail, we expanded the selective review protocol by [17] through a generic search over specific research outlets. In the second stage, we executed the literature search, conceptualized the dimensions for our framework and analyzed the results. Ultimately, we reported the results and our findings.

Search strategy. The search strategy involves two parts: a (1) selective part in which we apply the SLR approach through a search string to specific databases and a (2) generic part which analyzes all CSCW conference proceedings (c.f. Figure 2).

For the selective part, we started our search strategy by identifying an initial search string and selecting specific databases. Throughout several iterations of refinement, we obtained the final search string (see Table 1). To elaborate the search string, we set up three versions of the basic string in an initial step and executed it on Google Scholar. By reviewing the results, we identified 52 papers which were of potential relevance for matching the research idea. For refining our search, we extracted relevant keywords applied and enriched our search string. In addition, several synonyms were added. After iterative extraction and merging, we received the final string consisting out of three parts: (1) The first part referred to the concept of collaboration and its subconcepts. The second part describes concepts of (2) CT like groupware or CSCW. As the third and final aspect, terms of (3) psychological states like affect and cognition were used. To cover effects, we added a term for consequential behavior. Finally, the terms were combined with the Boolean operators OR and AND. As databases we selected initially Web of Science, the AIS electronic Library, EBSCO Host, ProQuest, Scopus, the ACM Digital Library, and IEEE Xplore. After reviewing the initial results, we focused on the first three databases, since they cover high-level journals and conferences in the IS domain. Since contributions to the research question presented include not only the IS field but also the CSCW field, a suitable expansion of the SLR approach was chosen.

For the generic part, we decided to apply a universal approach. We reviewed all conference proceedings of the conference for CSCW, the ACM Conference on Computer-Supported Cooperative Work & Social Computing which is specialized on collaboration through information systems.

Table 1. Initial and final search string.

Initial Search String	
AND	collaborative technologies OR collaboration technologies
	affect OR cognition OR behavior
	performance OR outcome
Final Search String	
AND	communication OR coordination OR cooperation OR collaboration OR team-work OR virtual team OR computer-mediated communication
	groupware OR technologies OR system OR social software OR social OR Web 2.0 OR group support system OR social media OR application
	affect OR emotion OR cognition OR user state OR performance OR outcome

Study Selection Criteria. Based on our research question, we meticulously selected the following search criteria: We only included peer-reviewed publications. Second, we excluded all non-empirical work and kept empirical studies only. Third, we focused on quantitative work, in order to focus on empirically evaluated and quantitatively grounded findings, since this allows to clearly identify investigated constructs. Publications with both quantitative and qualitative analyses were included, whereby only the quantitative part was evaluated. Fourth, we excluded any research in progress. Fifth, papers had to contain more than 5 pages. Sixth, only papers stayed in the sample that present a clear artifact design focus. Seventh, we restricted the search period to papers published from the year of 2000 on in order to preserve relevance of the publications. This decision was made due to fast technological advancements in the field of CT.

Paper selection and information extraction. The paper selection process involves six phases (see Figure 2 with selective and generic search part). During our selective search (Phases I-III), we queried elicited databases with the respective search term, applied search criteria in the search process, and derived a first sample through a title and abstract analysis. For the generic search part (Phases IV-V), we started with all ACM CSCW conference proceedings since 2000. Subsequently, we removed duplicates and applied a title and abstract screening. In phase VI, we merged the obtained results of the selective and the generic parts. Thereby, we applied a detailed examination following the search criteria, performed a forward-backward search, and received the final set of publications. Each part resulted in a number of publications and, finally, both results were merged in phase VI. As part of merging the two streams, a detailed screening and comparison was performed and further thematical inappropriate studies were excluded. After extracting selected studies, the publication sample was coded along bibliometric information (author, year, domain, and outlet) and the dimensions of the framework of analysis (CT type or SMT, user states and processes, and task- or non-task-related outcomes). In a subsequent step, focal

publication constructs were aggregated and assigned to a user state or process category. Based on this procedure, we analyzed the coding scheme and derived relevant results.

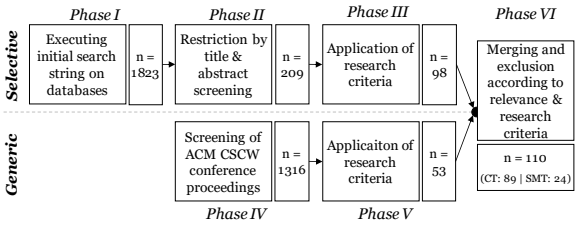

Figure 2. Study search process.

4. Results

In this chapter, we present the results of the SLR. First, we outline the results of our search strategy. Second, we present descriptive findings on CT and SMT, followed by a categorization of CT and SMT and user states and processes along the presented analysis framework following the S-O-R paradigm [19] and the integrative framework of workplace outcomes by [20].

Search strategy results

After querying the selected databases with the developed search string in the selective search part, we received a first collection of 1.823 publications. Subsequently, we examined these results based on title, abstract, and keywords, expelled duplicates, and extracted 209 publications for closer examination. After downloading the full text versions, we analyzed them in detail for the selected search criteria. This resulted in a selection of 98 scientific publications.

For the generic search part, we started with a total of 1.316 publications. After application of search criteria, duplicates removal, and title screening, we ended up with 53 potential publications. In phase VI, we merged the obtained results of the selective and the generic parts. Through a detailed examination regarding the relevance and fit as well as a forward-backward search, the final sample consisted of 110 publications.[1]

Descriptive analysis

Various relationships of CT and SMT studies which empirically investigated user states and processes were examined for descriptive evaluation. First, we analyzed the development of empirical research over time for CT and SMT. Overall, we identified 110 unique publication (89 CT and 24 SMT publications). Three publications focused on CT and SMT and were counted for both categories. The development over time of the publication count is presented in Figure 3. The figure shows the cumulative numbers of publications in the respective years. The number of publications in both domains is increasing continuously, while CT received larger interest in the beginning of the search period (from year 2000 on). In 2006 the research started to investigate SMT with a stronger focus on cognitive and affective user states and processes. This trend arose significantly in recent years, starting from 2010 and augmenting strongly since 2014. However, the body of research on CT is still larger than on SMT (+393%) in total. In relative terms, though, we observe a clear break in the last period. While the relative share of SMT (+3 to +5 between 2015 and 2017) remains positive, the number of publications for CT stuck compared to the previous period (+4 to +6 between 2015 and 2017).

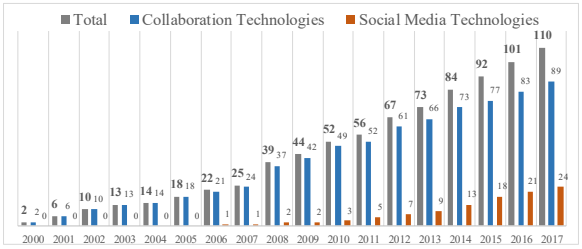

Figure 3. Distribution and share of publications over time between CT and SMT.

The distribution of the sample publications concerning CT on the four quadrants of the time-space matrix is presented in Figure 4 with regards to the abstraction of individual versus group level. The results show that most of the publications on both abstraction levels are investigating remote technologies. In detail, most studies have focused on synchronous and remote technologies. This is particularly evident at the individual level (cf. quadrant I+II and III+IV in Figure 4). The relative relationship between publications regarding the individual and group level is different between the dimensions of collaboration location. Within the areas of collocated collaboration (quadrant I, II), the relative difference accounts for 20% to 40%, while for remote collaboration (quadrant III, IV) it ranges between 65% and 100%. This represents a stronger focus on group studies in collocated collaboration.

[1] A list of the literature sample can be found here: https://bit.ly/3iuVztj

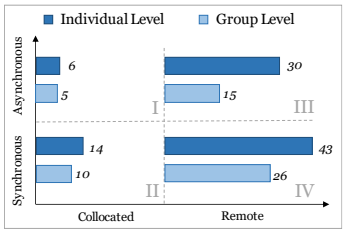

Figure 4. Distribution of results on time-space matrix (Multiple entries possible).

Framework analysis

Figure 5 displays the distribution of the complete literature sample along the framework of analysis and depicts the results on its dimensions (i.e., CT time-space matrix, user states and processes, workplace outcomes) independent of sub-samples (like in Figures 4, 6, 7) and of the level of analysis (individual/group) in a morphological box. Overall, more publications were carried out on the individual level (89 vs. group: 38). Likewise, the sectors of asynchronous - (38) and synchronous - (59) remote CT were investigated most thorough, followed by synchronous - collocated CT (18), while SMT are represented by 24 publications in the sample. Regarding user states, most publications focus on affect (84), followed by cognition (74). Regarding the concrete instantiations of affective states and processes studies focus in many cases on affective trusting beliefs [46], team cohesion [47], and affective aspects in social presence [48]. On the cognitive side, we report studies with cognitive load constructs [16], attention and awareness [49], and transactive memory on the group level [50]. Finally, regarding the outcomes, most studies focus on task-related outcomes like performance or effectiveness (37), while social outcomes like relationships or satisfaction receive less attention (17).

Level of Analysis	Group (38)			Individual (89)	
Collaboration Technologies	Asynchronous - Collocated (8)	Asynchronous – Remote (38)	Synchronous – Collocated (18)	Synchronous – Remote (59)	Social Media Technologies (24)
Affective and Cognitive User States	Affect (84)			Cognition (74)	
Outcomes	Task-Related Outcomes (37)			Social / Non-Task-Related Outcomes (17)	

Figure 5. Morphological box of framework dimensions (Multiple entries possible).

Figure 6 and Figure 7 present the results of our framework analysis along our research framework and allow for comparison between the individual and group level. Arrows depict the amount of publications. The width of the arrows symbolizes the absolute number of investigations between the dimensions and their categories. Publications that examined both levels were used in both analyses.

Individual level. On the individual level, the two subclasses of asynchronous - remote CT and synchronous - remote CT are particularly noteworthy. Most connections originate from them. The remaining two subclasses of CT are mentioned less often, while SMT are studied the weakest. Both, asynchronous - remote and synchronous - remote CT reveal the strongest relationship with affect. Asynchronous - collocated with overall little investigation shows equal connections to affect and cognition. Investigations between user states and processes and outcomes were carried out the strongest between cognition and task-related outcomes (20). Overall, many studies investigate task-related outcomes, while social outcomes like satisfaction receive less attention.

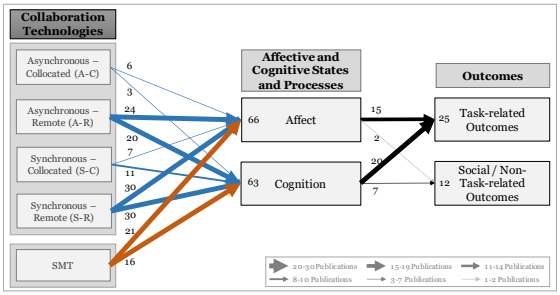

Figure 6. Analysis framework results on individual level (Multiple entries possible).

Group level. On the group level, most of the publications are investigating CT while only few have empirically investigated impacts of SMT on user states and processes. The strongest connections between CT and user states and processes resemble between synchronous - remote technologies. The strongest connection thereby exists with affective states, whereby most publications are based on the sub-class of synchronous - remote CT (21). Overall, affect has the highest frequency of investigation. As on the individual level, task-related outcomes (15) dominate social-related outcomes (10). Comparing the two levels, individual and group, synchronous - remote CT receive most attention in both cases by the sample studies. Regarding their difference, however, SMT are underrepresented in group research. Further, the investigation of impact of cognitive user states and processes on task-related outcomes is higher in group studies compared to affective states in individual studies.

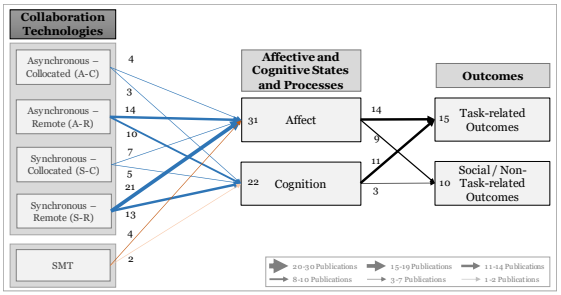

Figure 7. Analysis framework results on group level (Multiple entries possible).

5. Discussion

Research regarding the impact of CT on cognitive and affective user states and processes has been conducted in different streams since the emergence of GDSS and groupware in the 1970s. In order to identify contemporary research streams, we subsequently discuss the results of our advanced SLR. On this foundation, we propose future research avenues towards the next generation of CT which are more sensitive with regards to cognitive and affective user states and processes.

In our advanced SLR, we analyzed the body of IS literature as well as the ACM CSCW conferences since 2000. Our search strategy resulted in an initial set of 110 publications. When taking a closer look, the following pattern become obvious: Overall, empirical research focuses more strongly on individual level relationships between CT than on the group level (Δ=+134%). This is in line with the general trend which shows that more research is conducted on the individual level. Accordingly, this finding discloses a contemporary research shortcoming. While individual level research has received much attention, group level research remains underrepresented. This may be not due to a lack of interest, but rather since group level analysis implies an increasing level of complexity from a theoretical and empirical point of view [51].

Although the GSS research stream, for example, specifically addressed the group aspect [11, 52], our study confirms this trend. Further, our analysis focusses specifically on cognitive and affective user states and processes regarding CT. The group level increases the complexity due to open questions about the evolvement and the interplay of such states and processes [43, 53]. Our argument is supported by the fact that group level research is conducted more often in collocated scenarios which are better to examine than remote ones. However, the research community proposes untapped potential in the examination of group level insights. Constructs like trust, group potency, efficiency, or cohesion [30] could be further analyzed in order to better understand the nature of remote work. Therefore, while the individual perspective remains important, research on the impact of CT on user states and processes should be intensified on the group level.

In our study, we see an increasing focus on affect within CT and SMT research. This follows the shift in the IS domain from cognitive towards affective user states and processes. In this context, however, there is a broad spectrum of key focal elements. While some studies attempt to investigate fundamental affective constructs like positive or negative emotions [8] on the individual level, we rather observe abstract, higher level affect-related constructs like trust, cohesion, or group affective tone [30, 54] on the group level. This may induce additional complexity for understanding cognitive and affective states and processes. Research has not been able to come up with a unified and well-accepted theory regarding the interplay of cognition and affect. While there is consensus about basic affective concepts (e.g. emotion, feeling) as well as cognitive concepts (e.g. attention, shared mental model) [36], their interplay in the human brain has not yet been consensually understood. Extant theories posit either cognition before affective reactions (e.g. cognitive appraisal theories), affect before cognition (e.g. radical behaviorism) or propose affectless approaches (cognitive information processing) [55]. In summary, uncertainty about the mechanisms how user states and processes lead to human reactions prevails. Our findings document an increasing relative level of affect focus on the group level. This is also recognizable in related research on virtual teams, often culminating in trust. A potential reason might be the strong belief in the importance of the affective dimension in groups [30]. In contrast, research on the cognitive dimension is more constrained since it describes mainly two categories, team mental models and transactive memory [56]. Therefore, our findings document research on manifold affective constructs which either lack aggregation and conceptualization (affect) or detailed exploitation (group level cognition). This may lead to partial confusion for future researchers and practitioners.

Altogether, empirical research on remote CT is dominating our analysis. This accounts for asynchronous CT like emails, but especially for synchronous CT like instant messaging and video conferencing. Our finding reflects the general trend of remote collaboration which has been accelerated through the recent COVID-19 pandemic [4]. Until

now, remote collaboration has not been able to fully complement the transfer of social, non-verbal signals comparable to face-to-face meetings. This lack of social information or cues might have severe negative impact on emotional interpretation of the communication partners [57] as well as individual affective states and processes. When taking a closer look on our results, the included studies focus e.g. on affective constructs like affective commitment [58], affective trust [59], or social presence [60]. Since dissatisfaction still exists in many use-cases of remote collaboration like limited bonding capabilities in video conferences with new team members, it is desirable to improve the impact of CT on affective states. Therefore, research should transfer existing descriptive knowledge about the impact of CT on affective states and processes into prescriptive knowledge in order to develop innovative CT features. This development is visible since the beginning of the COVID-19 pandemic in CT like MS Teams or Zoom. These tools develop and offer new features in order to cope with the increasing demand and specific requirements of the users. Here, research and practice come closer together and create innovative real-world impact. Examples are the possibility to create sub-meetings within overarching group meetings or the attachment of reactions in form of emoticons.

On the other hand, technological limitations are likely to have severe negative implications beyond collaborative aspects. Limited transportation capacity for social signals not only prevents from group affiliation processes, but also increases social isolation [61, 62]. In order to neutralize these hazards, research needs to focus on the relevant affective constructs to measure and balance those risks.

To conclude, our study provides an overview of the relationship of CT and cognitive and affective user states and processes in research since 2000. Our results show an increase in research interest on remote CT, accompanied with a focus on affective constructs. This remote focus, however, remains stronger on the individual level, while group level research concentrates more strongly on collocated scenarios. Based on these findings, we see three main consequences. First, most studies focus on the individual level regarding user states and processes. Group level research is still underrepresented although there are prominent research streams like GSS (e.g. [11, 52]). Therefore, overcoming the reported obstacles is recommended. The community should facilitate such research in order to exploit its vast potential. Second, affect is in the focus of current CT research. However, future research should develop a clear understanding of the manifold affective constructs grounded in theory. Simultaneously, the interplay with cognitive states and process still lacks unified understanding. Before advancing more empirical research, a clear conceptualization of the interplay of cognitive and affective constructs is important. A continuous exchange with the related fields in psychology might be beneficial. Finally, remote studies are prevalent in our results. Considering the new normal, i.e. the changing environment which facilitates remote work, we see the need for developing more theoretically grounded prescriptive knowledge beyond the existing conceptual findings in order to offer innovative CT features that mitigate the existing downsides of remote work and contemporary CT solutions. These new features should be shaped whilst considering cognitive and affective states and processes in working groups.

6. Limitations and Future Research

Some limitations may apply to this study. First, individual characteristics such as age, gender, nationality as well as personality traits were not included. These factors capture further relevant information about the users and do interplay with cognitive and affective user states and processes. Future research may provide more specific insights into these important dimensions. Second, we have focused on certain scaffolds, such as the framework of workplace outcomes [20] and the time-space matrix [18]. However, other conceptualizations like the Wheel of Collaboration Tools [31] do exist. Future research might expand on this. Third, regarding SMT, we did not choose to investigate detailed aspects. In the future, research might focus on the development of more granular SMT classifications based on an in-depth analysis of SMT impact on cognitive and affective states. Finally, the framework of analysis remained on the level of cognition and affect as well as task- and non-task-related outcomes. All these categories could be analyzed in more detail with regards to more specific constructs. We therefore encourage research to take this study as starting point for fine granular literature analyses of specific cognitive and affective subcategories in the future.

7. Conclusion

CT are fundamental in facilitating workplace collaboration. In this study, therefore, we conducted an advanced SLR about the relationship of CT and cognitive and affective user states and processes. We screened more than 3.000 studies published in the IS and CSCW fields, resulting in 110 relevant

publications. Based on an integrated framework derived from the time-space matrix [18], the S-O-R paradigm [19], and the framework of workplace outcomes [20] we analyzed existing research. Our results show an increase in remote CT, along a focus on individual analysis and affective constructs, while group level studies concentrate relatively stronger on collocated scenarios. We contribute to research with implications and future research directions we derive from our results as the underrepresentation of group level research and constructs, a unified understanding of the interplay of affective and cognitive constructs, and the derivation of design knowledge for CT features which are sensitive regarding cognitive and affective user states and processes to counteract negative implications like social isolation and impaired group formation. With this work we provide researchers and practitioners a reference point towards future research directions for advanced, cognition- and affect-sensitive CT for a more efficient and meaningful collaboration in future workplaces.

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