Intentional Forgetting in Socio-Digital Work Systems: System Characteristics and User-related Psychological Consequences on Emotion, Cognition, and Behavior

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Abstract. Future work environments will offer technical applications to manage increasing amounts of information for organizations, teams, and individuals. In this context, psychological concepts of intentional forgetting (IF) can be applied to improve the performance of work systems or to extend the cognitive capacities of humans in technical systems. Different IF mechanisms have been suggested for assisting technology-aided IF, such as: (1) filtering of irrelevant or distressful information (e.g., by suppressing, deleting, or selecting), (2) delegating tasks from human to digital agents, changing roles, and reorganizing socio-digital work systems, or (3) systematic (re-)placement of retrieval cues or triggers to generate or suppress behavior. Due to these different underlying IF mechanisms, the implementation of IF at the individual, team, and organizational level will differ substantially between work areas or systems. In order to gain a better understanding of how socio-digital applications of IF impact human behavior and reactions, it is necessary to differentiate between relevant characteristics of socio-digital IF systems and gain an understanding of how these characteristics impact users' attitudes and performance. Thus, the present paper aims to classify and compare these characteristics of different applications of IF and introduces variables and methods to study psychological effects on users' behavior, experience, and affective reactions.

Keywords: Intentional Forgetting, cognitive capacity, transactive memory systems, unlearning of routines, user experience.

1 Intentional Forgetting in Socio-Digital Work Systems. Theoretical and Empirical Perspectives

Through the adaptive function of "goal-directed” or “intentional forgetting" (IF), humans can process large amounts of information and delete, overwrite, suppress, or sort out information that is no longer relevant [1]. In times of increasing amounts of information, this evolutionary success concept can be implemented in socio-digital systems of organizations in order to support employees in their work processes and to make technical systems work effectively and efficiently. Applications of psychological concepts of human IF in socio-digital work systems are diverse [2]. They range from individual user systems (e.g., assistance systems for selective information transfer), to collective work systems with human and digital agents, and organizational applications of IF [3]. Despite these various fields of application, a systematic comparison of the conceptual IF approaches is still lacking. What are the core mechanisms of IF implemented in such systems? What are the specific characteristics of technical implementations that human users have to deal with when using such systems? The comparability of different socio-digital IF systems is of great importance for theoretical, as well as for application and work-design oriented questions. In this vein, this paper distinguishes mechanism of IF into three general categories: filtering, delegating, and (re-)placement. Also, specific system characteristics are identified to further describe and compare the applications. From the perspective of industrial and organizational psychology, IF system characteristics must be designed to meet both, the technical challenges as well as the users' needs. Thus, the paper reflects psychologically relevant variables that might be affected by IF systems, such as human behavior, affective reactions, and the users' willingness to use the technology [4]. In the second part of the paper, six applications of IF are introduced. The aim is to demonstrate applications of theoretical IF concepts. Additionally, the concept of a comparative study which integrates several research projects on IF will be presented. This approach enables researchers to systematically investigate the effects of differing IF system characteristics on psychological experiences and behavior. The paper concludes with a reflection of further research perspectives for studying and comparing IF systems.

2 Classification of IF Mechanisms and System Characteristics. Effects on User Reactions in Socio-Digital Work Systems

Psychological concepts of IF derive from various fields of psychology, in particular, cognitive sciences as well as team and organizational research [2]. In the field of cognitive science, the concept of IF can be traced back to the seminal work of Golding and MacLeod [5] with contributions on intended and unintended forgetting within individual memory [6]. Intended forgetting is considered a goal-directed process in reaction to an explicit or implicit cue. Unintended forgetting is associated with inhibition or suppression of information in memory [6] (for reviews and historical perspectives, see [7, 8]). Besides the individual cognitive perspective, IF can also be transferred to the team and organizational level. Within each field of research, specific theoretical concepts and terminologies are applied [2]. In order to provide a simple terminological framework for these different approaches, we differentiate the existing theoretical concepts into three categories: filtering, delegating, and (re-)placement (see also table 1). Within these categories, we distinguish application systems of IF that support the user in dealing with increasing amounts of information by applying theoretical concepts of IF. Differences can be found in the target variables and mechanisms of IF. Although all concepts aim at forgetting knowledge elements, targets and approaches are very different. This variety makes it possible to install very different application systems in socio-digital work systems in order to support users in their knowledge work.

Filtering. Filtering-based IF describes the process of organizing and presenting information according to its relevance for current tasks. Digital assistance systems reach this goal by hiding, suppressing, or deleting irrelevant and by highlighting relevant information. The digital systems can be based on different theoretical concepts of psychological forgetting, such as interference and retrieval theory [9] or theories of IF [7]. Specific applications of filtering are: “Semantic Desktop” that presents specific contents according to their current relevance (see project “Managed Forgetting”, chapter 3.1); “Cognitive Companion”, a system that helps users to decide which files can be archived or deleted and thereby get rid of irrelevant digital information (see project Dare2Del, chapter 3.2), or a computer-based decision support system (DSS) that presents information relevant for a concrete decision and thus triggers directed forgetting of stored background information (see “Trustful Forgetting” approach, chapter 3.3).

Delegating. This IF mechanism focuses on the distribution of knowledge or roles within groups. IF, for instance, can be implemented by redistributing expert knowledge or roles between humans and software agents. By delegating knowledge or roles, the individual is no longer required to store the delegated information. The redistribution of knowledge as an IF mechanism relates to theories of team cognition [10], and, more specifically, to so-called transactive memory systems. In these systems, individual experts hold specific divergent knowledge. Team members can access this knowledge by knowing who knows what [11, 12]. Transferring the concept of transactive memory systems, IF represents the reorganization of knowledge distribution in teamsm, which leads to an expansion of team members’ individual storage capacity [2]. Specific applications of delegating are collaborative work systems of human and digital agents with distributed knowledge, tasks, and roles. This can increase cognitive capacities and support forgetting (see project “AdaptPRO”, chapter 3.4).

(Re-) placement. Routines which are no longer relevant to a task can be replaced by the “installation” of new routines. Theoretically, the mechanism of (re-)placement is associated with the term unlearning [13, 14] in the sense of discarding and replacing old routines [15]. Specific applications of (re-)placement are found in intensive multi-actor production routines. In some applications of IF, recall of certain organizational

memory items is impeded, by deliberately eliminating retrieval cues that are associated with the to-be-forgotten routine (see the project “Intentional Forgetting, routines, and retrieval cues”; chapter 3.5). Other applications use assistance systems that support the replacement of undesirable work-related habits (see the project “Intentional Forgetting of Everyday Work Behavior”; chapter 3.6).

Table 1. IF mechanisms, theoretical foundation, and technical solutions in project examples.

IF mechanisms in socio-digital systems			
	Filtering	Delegating	(Re-)placement
Targets of IF	Suppressing/archiving/deleting/selecting of irrelevant/relevant information, symbols, etc.	Distributing expert knowledge or roles of an agent within group work	Established behavioral routines and habits are unlearned
Technical context of IF	Support of human information processing through technical assistance systems, e.g., desktop symbols	Digital software agents as part of a work-group	Technical systems provide cues to unlearn routines and to replace undesirable habits by more desirable ones
Theoretical foundations of IF	– intentional forgetting [7]	– team cognition / transactive memory systems [16]	– unlearning of routines [15] – habit change
Project examples	– Managed forgetting [17] – Dare2Del [18] – Trustful Forgetting [19]	– AdaptPRO [20]	– Intentional Forgetting, Routines & Retrieval Cues [21] – Intentional Forgetting of Everyday Work Behavior [22]
Characteristics of socio digital IF systems	– Voluntariness of system use – Level of Automation / Adaptability – External versus internal triggers of IF – Individual, team, and organizational level of IF – Understanding of system IF		
User reactions	*Forgetting effects*: e.g., release of cognitive capacities, unlearned routines, low errors etc. [4] *Further effects of IF systems on users* – behavior: intention of using the system, perceived benefit [4] – cognitive: trust in technical system [23] – affective: techno stress [24], satisfaction [4], affective trust, well-being [24]		

Differentiating IF mechanisms of filtering, delegating, and (re-)placement makes it possible to examine and compare the forgetting effects on cognitive capacities or user performance. These key dependent variables of IF are operationalized in several ways. For instance, users' information load can be decreased or the effectiveness of learning new routines can be increased by intentionally forgetting old ones [4]. From a psychological perspective, however, there are further individual effects to be considered, when introducing a digital IF system at work. Behavioral, cognitive, and affective reactions of users may determine, whether an IF system can be applied successfully at the workplace. From technology acceptance research it is known, that the setup of technology can influence user behavior or perceived usefulness of the technology (technology acceptance model, TAM, [4], Unified Theory of Acceptance, UTAUT [25]). Research on human-automation-interaction (HAI) shows that technology characteristics are associated with performance and affective reactions (e.g., errors, threat, stress, satisfaction) [24]. The system setup can also influence users cognitive reactions towards the technology, such as vigilance or the degree of trust users have in the system [23, 26]. These findings can further be transferred in order to evaluate effects of IF systems on users in socio-digital workplaces. In order to systematically analyze direct or moderating influences of IF systems on user behavior, as well as cognitive and affective experiences, it is necessary to differentiate the characteristics of the IF systems. It should be noted that these characteristics are not exhaustive, but represent only a sample that is of particular interest to the projects presented here (see discussion for further perspectives).

Voluntariness. Originally proposed as part of the TAM3, voluntariness describes the „extend to which potential adopters perceive the adoption decision as not-mandatory" [27]. In the context of IF systems, this raises the question of whether individual users have the choice to use the system voluntarily. An example of a voluntary use could be the placement of cues within the software for guidance. The user then has the choice to either make use of the cues or to ignore them. UTAUT identifies voluntariness as one of four moderators (i.e., age, gender, experience, and voluntariness) that are related to behavioral intentions to use a technical system in organizational contexts [25]. For IF systems, a high degree of voluntariness should facilitate the experience of user control and thus increase the intention to use the system.

Level of IF-Autonomy (LOA). Systems can differ in their degree to which the user can influence the IF system's information or task processing settings. Taken from HAI-research [28], this characteristic describes the degree of autonomy of an IF system. Thus, LOA also indicates the extent to which the user is able to manually intervene. With a high IF autonomy, the filtering of information, the delegation of decisions, or the setting of cues take place with no human intervention or adjustment possibilities. For example, DSS may differ in the level of autonomy at which they support users. With full autonomy (level 10) DSS would generate and execute decisions themselves. By reducing processing requirements of the user, this also leads to a high capacity reduction (forgetting) for the user. At the medium level, the IF system of a DSS would allow the user to veto actions before executing them. On low levels, the system offers a set of decision alternatives. The LOA not only effects forgetting in terms of workload and cognitive capacity, but it also has a large impact on performance in routine versus out-of-loop situations [26].

Moreover, LOA is associated with affective reactions such as system trust [26]. When users perceive the LOA as helpful with appropriate degrees of control in certain situations, it results in higher system trust. Thus, another facet of LOA relates to its adaptability. LOA modes may be fixed or adjustable (e.g., defined by the user). Users report higher trust in automation that provides some level of control (i.e., the user has the authority over system function allocation, [26]). For research on effects of IF systems, LOA and its adaptability are relevant characteristics for predicting user reactions.

Trigger of IF. When humans forget, the forgetting process is, most often, internally triggered. Intentions, processes, and subsequent behavior are initiated and executed by the individual [6]. The described IF systems differ in the sense that in some systems forgetting is triggered internally (e.g., system adaptations based on user behavior), while others are triggered externally (e.g., when forgetting through delegation is implemented by management). We assume that internal triggers are more coherent with individual behaviors and lead to higher levels of system trust and satisfaction.

Level of IF. Forgetting systems can differ in their level of implementation, such as individual level [29], group level [30], or organizational level [3]. Although the focal phenomenon is individual technology acceptance and use, it is necessary to differentiate the effects on a meso level [25]. The implementation of IF systems at the team and organizational level also involves group level coordination, cooperation, and communication processes [31], as well as social dynamics. Therefore, the IF system's effects on behavior, cognition, and affect may differ from IF systems applied at the individual level.

Understanding IF. Both, models of usability [25] and HAI [26] underline the importance of user experience or understanding. User understanding and overall transparency of the underlying mechanisms, goals, and implemented IF processes are therefore important characteristics of IF systems. In line with the literature, it can be assumed that understanding IF characteristics will increase performance expectancy and thus increase overall acceptance, intention to use [25], as well as system trust [26].

The characteristics presented are only a limited selection of possible factors influencing the experience and behavior of IF system users. Comprehensive overviews of system characteristics can be found at [25] and [26]. In the following section, applications of IF systems will be presented, and the approaches of comparing user reactions will be illustrated.

3 Examples of Applications and Comparative Studies on IF in Socio-Digital Work Systems

We argued that IF systems have to be differentiated concerning (1) the mechanisms of IF and (2) the characteristics of the IF system. Furthermore, we pointed out that the described mechanisms and characteristics can lead to different cognitive, affective, and behavioral user reactions. Thus far, when studying IF systems, studies mainly look at software solutions in specific contexts. This makes comparisons between studies difficult. Without an overarching classification of IF systems, generating generalizable results is not possible. Therefore, we recommend that when studying IF systems, IF should be classified concerning the underlying mechanism (i.e., filtering, delegating, and (re-)placement) as well as the characteristics of the IF system (e.g., voluntariness, LOA, triggers, level, and understanding). By utilizing such a classification system, we can generate generalizable results, helping us to gain a better understanding of users' cognitive, affective, and behavioral reactions when working with IF systems.

In the following we introduce an exemplary procedure of how to comprehensively study the effects of IF mechanisms and IF system characteristics across six projects of the priority program "Intentional Forgetting in Organizations" funded by the German Research Foundation (DFG SPP 1921). Each project develops IF systems for socio-digital workplaces. The applications developed in the projects utilize different IF mechanism and system characteristics and further focus on different settings. We first give a brief overview of the exemplary procedure and design of the comparative study, followed by a more detailed introduction of each of the projects. Additionally, we describe a planned comparative study of the different projects.

Exemplary Procedure and Design of Comparative IF Study. Each project is conducting experimental applications of IF systems differing in the described IF mechanisms and system characteristics. Following the initial experiment of each project (lasting between 60-120 mins), participants receive a cover story (vignette). The vignette text describes the situation of being in a future work environment using the IF system participants have worked with in the initial experiment. Participants are then asked to complete a survey and rate their behavioral and affective reactions, their trust in the IF system, as well as their willingness or intention to use the IF system. Comparing user reactions between the different IF systems, each implementing different IF mechanisms, allows for evaluating reactions at different levels of IF system characteristics. In the following, the six research projects are described concerning the socio-digital application of IF, the theoretical framework, and the addressed psychological effects.

Table 2. IF mechanisms and applications in project studies.

	IF concept and project application	(1) Project study design (2) System characteristics in comparative study (vignette design: VO = Voluntariness, LOA = Level of Autonomy, TR = Trigger, LE = Level, UN = Understanding)
Managed forgetting [17]	*Filtering*: Semantic Desktop. IF by hiding and suppressing irrelevant information	*Design*: Two experimental task sequences (ca. 60min) with an implementation of semantic desktop, N = 48, student sample *Vignette*: VO: Low; LOA: High vs. Medium; TR: Internal; LE = individual system; UN = high

Dare2Del [18]	*Filtering*. Cognitive companion that fades out irrelevant information	*Design*: Two experimental task sequences with new rules/relevant information (ca. 60min), N = 30, student sample *Vignette* VO: Low vs. High; LOA: High; TR: External; LE = individual system; UN = Low vs. High
Trustful Forgetting [19]	*Filtering*. Decision Support System (DSS) that automatically selects information	*Design*: experimental task manipulating DSS characteristics (ca. 60min), N = 200, student sample *Vignette* VO: Low vs. High; LOA: High; TR: External; LE = individual system; UN = Low vs. High
AdaptPRO [20]	*Delegating*. Cognitive capacity relief through delegation of specialist knowledge to autonomous software agent (SA) in a team task	*Design*: experimental team manipulating IF through knowledge distribution (specialist vs. generalist) (ca. 90min), N = 60 teams of three (one SA, two humans), student sample *Vignette* VO: Low; LOA: High vs. Medium; TR: External; LE = team system; UN = Low vs. High
Intentional Forgetting, Routines & Retrieval Cues [21]	*(Re-)Placement*. Ignoring previous production rules/routines	*Design*: experimental factory setting with two production phases (each 60min) within 8 days, N = 72, student sample/worker sample *Vignette* VO: Low; LOA: Low vs. High; TR: External; LE = individual and team system; UN = Low vs. High
Intentional Forgetting of Everyday Work Behavior [22]	(Re-)Placement. System provides reminders to unlearn undesired habits	*Design*: experimental setting (60min), student sample/worker sample *Vignette* VO: Low vs. High; LOA: High vs. Medium; TR: External; LE = individual system; UN = Low vs. High

3.1 Managed Forgetting. Sustaining Grass-roots Organizational Memories: Foundations and Methods of Managed Forgetting for Knowledge Workers [17]

IF system. In this project a personal information management system, called Semantic Desktop [32], functions as a reliable external memory store. The Semantic Desktop organizes and integrates all stored information in a semantic network and decides which information is currently relevant and which is not. The system forgets by hiding and suppressing irrelevant information. This provides a working environment for assisting users in focusing on current task demands.

Task Application and Forgetting. In future laboratory experiments, participants use the Semantic Desktop as their external memory store, while performing the main task (e.g., internet research about a particular topic). After a sudden task switch, participants can either rely on the Semantic Desktop to store progress in the first task or not, affecting performance in a secondary task (taxing working-memory capacity; e.g., solving arithmetic problems). Benefits for performing the secondary task occur when users are able to offload all progress onto the system. In addition to reducing cognitive load, the system only provides the user with task-relevant information when returning to the main task. Thus, forgetting is triggered internally, assisting the user with the described benefits of forgetting.

Comparative Study. Following the experiment, the participants receive a description of a scenario (vignette) in which they should imagine using the semantic desktop in future work environments. The condition of the system characteristic LOA will be varied by instruction. We assume that the participants show a higher intention of using the system when they are promised to have control about the filtering process (e.g. being able to undo single steps of filtering). Furthermore, the IF system is characterized by a high UN. Participants are well informed about the functions and possibilities of this system and can therefore better grasp potential benefits of using it. It is assumed that this transparency leads to more trust in the system and again a higher intention of using it.

3.2 Dare2Del. Internal and external IF – Empirical studies and development of an assist system for IF of digital information [18]

IF system. Dare2Del is a context-sensitive cognitive companion which supports workers in temporarily ignoring, permanently archiving, or deleting outdated information, enabling them to deliberately control their forgetting in the workplace [33]. Dare2Del is based on an approach of interactive learning where the system can explain its decisions to the human. Human feedback is acknowledged to adapt the knowledge base of the system. The cognitive companion is conceptualized as a so-called white-box learning system, which combines classic knowledge-based approaches [34] and machine learning.

Theoretical Foundation of IF. IF refers to a targeted attempt to limit access to information in memory that is emotionally distressing, unwanted, or irrelevant to task processing, such as an outdated work process or a conflict with one's supervisor [7]. As research on intentional forgetting focuses on forgetting memory contents, we extended this approach to the forgetting of electronically-stored information objects, such as emails and files in socio-digital systems. IF, with respect to digital objects, refers to hiding, filing and archiving, or deleting of digital information. It is important to differentiate actions that serve the implementation of IF (i.e., deleting, archiving, filing, or hiding) from IF, as the described actions can also take place independently of IF.

Task Application and Forgetting. By combining the directed forgetting paradigm [1] with the task-change paradigm [35, 36], we examine whether fading out of task-irrelevant information supports individual forgetting with positive consequences for task performance. In the first phase of the experiment, participants have to develop a routine to proof medication plans for patients according to prescribed rules. After routine development, rules change and participants have to proof the medication plans according to new rules. In the main experiment we compare three experimental conditions: IF condition, assisted condition (fading out of irrelevant information), and remember condition. As dependent variables, we measured performance (task performance, rule violations) and recall rates of old and new rules.

Comparative Study. After the experiment, the participants receive a description of a scenario (vignette) in which they should imagine using the cognitive companion Dare2Del in future work environments. Dare2Del is described as a system with a high level of system autonomy which triggers IF externally by fading out irrelevant information. The system characteristics "voluntariness of use" and „user understanding" will be varied by instruction. We assume that participants trust Dare2Del more, and are more likely to have the intention to use it when they have a choice to use the system voluntarily. Further, we assume that understanding the underlying system mechanisms and goals increases user intention.

3.3 Trustful Forgetting: Motivational and emotional influences on intentional forgetting in organizations [19]

IF system. Storing and processing vast amounts of data, the applied DSS automatically selects information that is relevant for a concrete decision and exclusively presents this relevant information to the user.

Theoretical Foundation of IF. In times in which decision-makers have to process growing volumes of information [37], forgetting can be beneficial for both, organizations [38] and information overloaded employees [39]. Cognitive research has shown that individuals can forget when directed to do so and that directed forgetting releases resources for additional tasks [40]. We consider DSSs that process and analyze massive amounts of data [41] as a structural trigger of directed forgetting. The availability of a DSS enables users to forget the data that is stored in the DSS and thus releases cognitive resources for further tasks. Trust in the DSS [42, 43] is regarded as a basic requirement of actual DSS use and successful forgetting.

Task Application and Forgetting. We transfer directed forgetting to more complex business settings in simulated sales planning decisions. With the help of the DSS, individuals have to distribute products of a fictitious bicycle manufacturing and sports company to five fictitious countries of sale. Directed forgetting is operationalized by providing a DSS that permits individuals to forget decision-relevant background information on prior sales numbers of the fictitious company that needs to be learned before the decision tasks. Context and DSS characteristics are manipulated as potential moderators of IF (economic dynamics, accountability, and distraction). In addition to several performance indicators, trust in the DSS, well-being and perceived strain are measured.

First results indicated that the forgetting effects depended on users' trust in the DSS. Moreover, the availability of a DSS released mental resources for additional tasks, increased decision makers' performance and well-being, and decreased their experienced strain [44].

Comparative Study. Following the experiment, the participants receive a description of a scenario (vignette) in which they should imagine using the DSS in future work environments. The condition of understanding will be varied by instruction. We assume that a deeper understanding will enhance trust in the DSS and, in turn, the intention to use it. Furthermore, the IF system is characterized by high LOA as it automatically selects relevant information. It is assumed that high LOA makes understanding an important factor for trust in the DSS.

3.4 AdaptPRO. Adaptive forgetting by emergent knowledge structures in socio-digital systems [20]

IF system. This project studies socio-digital teams, consisting of autonomous software agents (SA) and human team members while working together on a simulation task. In order to improve efficiency, tasks or complete roles can be delegated to the SA. The user can thus forget specific knowledge that is related to the delegated task or role. In the laboratory study, users' information capacity, strain, and performance are studied under varying conditions of task complexity, occurring disturbances, and user autonomy.

Theoretical Foundation of IF. IF is defined as an adaptive reorganization process of knowledge structures to changing environmental demands within the context of teams. This is based on theories of team cognition [12], arguing that by means of specialization of individual team members, information storage requirements can be decreased. Thus, distributed team cognition facilitates IF as well as an extension of memory capacity by the specialization of knowledge bases.

Task Application and Forgetting. Teams of three take part in a simulated firefighter task, controlling fire trucks that differ in properties (e.g., fire trucks can only extinguish specific buildings). Rules differ between teams: Each player has a set of fire trucks that either has the same properties (specialist team) or different trucks of each property type (generalist team). One of the team members is a SA, utilizing artificial intelligence for decisions, actions, and interaction with the other team members. In the simulation, the agent suggests options for knowledge delegation between the team members. This study utilizes a highly automated environment, that has a certain degree of voluntariness (users deciding to follow the SA's recommendations) but low adaptability. Trust, strain, and user behavior are studied as core dependent variables.

Comparative Study. Following the experiment, the participants receive a description of a scenario (vignette) in which they are asked to imagine working with autonomous software agents in a work team. The condition of LOA and understanding will be varied by instruction. We assume that subjects show a higher degree of system trust and user intention when the SA's capabilities, working methods, and limitations are transparent. Furthermore, this IF system is characterized by high LOA as it is not possible to manually change system settings or to correct SA behavior. It is assumed that high levels of LOA will result in lower user acceptance compared to IF-systems that allow manual control and intervention.

3.5 IF, Routines & Retrieval Cues [21]

IF system. In a special purpose setting of a learning factory (Research and Application Center for Industry 4.0/ RACI), teams have to switch to a new production routine. The RACI provides a hybrid simulation within which hardware equipment (i.e., transport systems, manufacturing robots, QR scanners) is enriched with software components.

Theoretical Foundation of IF. The research builds on three assumptions: 1) organizations possess a memory that is comparable to human memory [45] which is found in transformational processes such as routines [46]. Researchers investigating organizational routines [47, 48] or organizational forgetting [15, 49–51], stress the impact of routines on organizations' stability and lack thereof [13, 52]. 2) Organizational routines are "multi-actor, interlocking, reciprocally-triggered sequences of actions" [53]. 3) Retrieval theories [9, 54, 55] are used to actively support forgetting. The elimination of retrieval cues enables the weakening of memory items and therefore, forgetting. As a result the memory items are not activated because the related situational, sensory, or routine-related cues are not present [3].

Task Application and Forgetting. The teams produce artificial knee joints in the RACI as they need to be produced at a very high-quality standard by following a predefined procedure and are unique for each customer. In our experiments, participants visit the special-purpose factory setting twice, at day 1 and day 8. Day 1 includes the training of the participants in executing an interdependent multi-actor routine without errors and in a predefined period of time in a team of two workers. The routine of each worker includes eight steps, each requiring a maximum of six action elements and a total of 33 memory items that form the routine under investigation. Fifty percent of the routine needs to be forgotten at day 8.[56]. First results show that not all elements of a routine are forgotten at the same speed. Additionally, IF of routines depends on the characteristics of the steps changed in the sequences of the new routine compared to the old routine.

Comparative Study. Following the experiment, the participants receive a description of a scenario (vignette) in which they should imagine working in the production setting of the factory. The condition of the system characteristic LOA will be varied by instruction. We assume that variations of the explanation of the routine change and the presence of cues supporting this change affect high or low levels of LOA and understanding. It is assumed that an adequate explanation and precise cues enhance perceived benefit of and trust in the system. Working under this condition will be less stressful and more satisfying than working with an inadequate explanation and missing cues.

3.6 iVAA. IF of everyday work behavior: Assessment, formalization, and integration into interactive systems [22]

IF system. Habit change will be supported by a persuasive system that provides reminders (i.e., external triggers) and alerts the user of showing (or not showing) specific undesirable behaviors [57]. The system will be embedded in work situations, mainly in office contexts.

Theoretical Foundation of IF. The project addresses habits at work and mainly focuses on behavioral habits. It builds on the more general literature on habits [58, 59] and extends the insights from this research to workplace habits. Often, workplace habits are related to specific tasks, but may also occur independently from the execution of such tasks. Within this theoretical context, IF is the deliberate replacement of undesirable habits by alternative types of behavior. To achieve habit change in work settings, theoretical approaches that have been shown to be beneficial for habit change, in general, are considered, specifically the approach of using implementation intentions [60, 61] and the approach of vigilant monitoring [62].

Task Application and Forgetting. The application will allow for adaptation to various task settings. Because cues (i.e., triggers) play a crucial role in habitual behavior [63], users will be invited to identify the specific external (i.e., environmental) or internal (i.e., cognitive or emotional) cues that usually trigger their specific habits. Users will be encouraged to personalize the persuasive system so that it provides additional triggers that remind to respond differently to the already established external or internal cues. The focus will be on individual processes, although taking into account that habit replacement might be influenced by team and organizational factors.

Comparative Study. After having identified habit cues, the participants receive a description of a scenario (vignette) in which they should imagine using the persuasive system in a future work setting. Various aspects of the system could be manipulated. If particular interest will be the question when participants anticipate using the system (intention of system use) and if they expect that using the system will reduce stress experiences and will increase individual effectiveness and performance.

4 Discussion and Conclusion

Psychological concepts of IF originate from different disciplines of psychology [62]. In addition to the individual concepts of IF, which originate primarily from cognitive psychology, approaches of team research and organizational psychology complement the understanding of IF. Categorized by the mechanisms of filtering, delegating and (re-)placement we have presented theory-driven application systems that make forgetting applicable in socio-digital workplaces. The systems aim to use forgetting mechanisms to make information quantities manageable, to replace old rules with new ones, or to expand cognitive capacities. Finally, three perspectives are highlighted for guiding future research to gain a deeper understanding of user experience and behavior when interacting with IF systems.

Perspective 1: Cognitive Capacity and Forgetting. We propose that the implementation of individual, team, and organizational IF mechanisms in socio-digital systems can increase information processing capacity and performance of the whole systems. Future research should address the long-term effects of IF systems on vigilance, problem-solving, and fault management. Current research in pre-defined and controlled settings can give insights into specific IF mechanisms. The application, however, takes place in a complex and dynamic interdependent system in which numerous influences of the person, the task, and the environment have to be considered.

Perspective 2: Understanding IF systems. Understanding and knowledge about the IF system can affect system trust and users' affective reactions. Research shows that transparency is a crucial factor in order to develop trust when interacting with other people or systems at work [64]. IF systems integrate new and often highly complex IF mechanisms into users work environments. It is therefore essential to understand the benefits as well as the costs of teaching users about the underlying IF mechanisms and how this understanding impacts user reactions. It is known from team research on transactive knowledge systems that meta-knowledge about the skills and limitations of team partners is an important factor for faith in one's abilities within the system, as well as for trust in the system [64]. Creating meta-knowledge about the IF system as a "digital teammate", is therefore, a further field of research.

Perspective 3: Task Type, Autonomy, and Adaptability. The IF applications represent automation within specific tasks, for example, the selection of information on the monitor, the support of decisions, the delegation of roles in task execution, or the automated reminder of action routines. Based on the findings of automation research, three system-related characteristics must be taken into account when developing and investigating IF systems. These characteristics influence very different variables of performance and user reaction [26, 28]. (1) The LOA and its effects on performance and reactions. Depending on the application, the user is given more or less control over the execution of the action. (2) The degree of adaptability of the IF system must be identified. As in many automated applications, the question arises whether users can change the degree of automation in certain situations, even to the point of switching off the IF system. (3) The types of tasks in which the automated IF systems are used. For example, Endsley and Jones [65] differentiate "monitoring and information presentation", "option generation", "decision making/action selection", and "implementation of action". Thus, future research should investigate how LOA, adaptability, and task type affect the acceptance and performance of users in IF systems.

In conclusion, research and application of IF in socio-digital work systems depend on interdisciplinary cooperation and comparative research studies across projects. In addition to the field of cognitive psychology, insights from team research and organizational psychology provide important impulses for research on IF. The implementation of IF in digital systems also requires contributions from Human-Automation Research and Human Factors. Finally, close cooperation between psychology and the implementing informatics is necessary in order to implement IF in future work systems successfully.

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References

1. Bjork, E.L., Bjork, R.A., Anderson, M.C.: Varieties of goal-directed forgetting. Intentional forgetting Interdiscip. approaches. 103, (1998).
2. Ellwart, T., Kluge, A.: Psychological Perspectives on Intentional Forgetting. An Overview of Concepts and Literature. Manuscr. Submitt. Publ. (2018).
3. Kluge, A., Gronau, N.: Intentional Forgetting in Organizations: The Importance of Eliminating Retrieval Cues for Implementing New Routines. Front. Psychol. 9, 51 (2018).
4. Venkatesh, V., Bala, H.: Technology Acceptance Model 3 and a Research Agenda on Interventions. Decis. Sci. 39, 273–315 (2008).
5. Golding, J.M., MacLeod, C.M.: Intentional forgetting: Interdisciplinary approaches. Psychology Press (2013).
6. Macleod, M.D., Bjork, R.A., Bjork, E.L.: Types and Consequences of Forgetting: Intended and Unintended. In: Memory and Society. pp. 144–168. Psychology Press (2013).
7. Anderson, M.C., Hanslmayr, S.: Neural mechanisms of motivated forgetting. Trends Cogn. Sci. 18, 279–292 (2014).
8. Brand, M., Markowitsch, H.J.: Forgetting: A historical perspective. In: Forgetting. pp. 37–48. Psychology Press (2010).
9. Roediger III, H.L., Weinstein, Y., Agarwal, P.K.: Forgetting: preliminary considerations. In: Forgetting. pp. 15–36. Psychology Press (2010).
10. DeChurch, L.A., Mesmer-Magnus, J.R.: The cognitive underpinnings of effective teamwork: a meta-analysis. J. Appl. Psychol. 95, 32–52 (2010).
11. Ellwart, T., Konradt, U., Rack, O.: Team mental models of expertise location: Validation of a field survey measure. Small Gr. Res. 45, 119–153 (2014).
12. Zajac, S., Gregory, M.E., Bedwell, W.L., Kramer, W.S., Salas, E.: The cognitive underpinnings of adaptive team performance in ill-defined task situations: A closer look at team cognition. Organ. Psychol. Rev. 4, 49–73 (2014).
13. Fiol, C.M., O'Connor, E.J.: Unlearning established organizational routines–Part II. Learn. Organ. 24, 82–92 (2017).

14. Huber, G.P.: Organizational learning: The contributing processes and the literatures. Organ. Sci. 2, 88–115 (1991).
15. Tsang, E.W.K., Zahra, S.A.: Organizational unlearning. Hum. Relations. 61, 1435–1462 (2008).
16. Hollingshead, A.B.: Retrieval processes in transactive memory systems. J. Pers. Soc. Psychol. 74, 659 (1998).
17. Frings, C., Dengel, A., Niedernée, C., Tempel, T.: Managed Forgetting. Sustaining Grass-roots Organizational Memories: Foundations and methods of Managed Forgetting for Knowledge Workers [Scholarly project].
18. Niessen, C., Schmid, U.: Dare2Del . Internal and external IF – Empirical studies and development of an assist system for IF of digital information [Scholarly project].
19. Hertel, G., Becker, J.: Trustful Forgetting: Motivational and emotional influences on intentional forgetting in organizations [Scholarly project].
20. Ellwart, T., Antoni, C.H., Timm, I.J.: Adaptive forgetting by emergent knowledge structures in socio-technical systems [Scholarly project], http://www.spp1921.de:8442/projekte/p1.html.de.
21. Kluge, A., Gronau, N.: IF, Routines & Retrieval Cues [Scholarly project].
22. Sonnentag, S., Weyers, B.: iVAA. IF of everyday work behavior: Assessment, formalization, and integration into interactive systems [Scholarly project].
23. Mcknight, D.H., Carter, M., Thatcher, J.B., Clay, P.F.: Trust in a specific technology: An investigation of its components and measures. ACM Trans. Manag. Inf. Syst. 2, 12 (2011).
24. Ragu-Nathan, T.S., Tarafdar, M., Ragu-Nathan, B.S., Tu, Q.: Consequences of Technostress for End Users in Organizatios: Conceptual Development and Empirical Validation. Inf. Syst. Res. 19, 417–433 (2008).
25. Venkatesh, V., Thong, J.Y.L., Xu, X.: Unified theory of acceptance and use of technology: A synthesis and the road ahead. J. Assoc. Inf. Syst. 17, 328–376 (2016).
26. Schaefer, K.E., Chen, J.Y.C., Szalma, J.L., Hancock, P.A.: A meta-analysis of factors influencing the development of trust in automation: Implications for understanding autonomy in future systems. Hum. Factors. 58, 377–400 (2016).
27. Venkatesh, V., Davis, F.D.: A theoretical extension of the technology acceptance model: Four longitudinal field studies. Manage. Sci. 46, 186–204 (2000).
28. Parasuraman, R., Sheridan, T.B., Wickens, C.D.: A model for types and levels of human interaction with automation. IEEE Trans. Syst. man, Cybern. A Syst. Humans. 30, 286–297 (2000).
29. Anderson, M.C.: Rethinking interference theory: Executive control and the mechanisms of forgetting. J. Mem. Lang. 49, 415–445 (2003).
30. Hinsz, V.B., Tindale, R.S., Vollrath, D.A.: The emerging conceptualization of groups as information processors. Psychol. Bull. 121, 43 (1997).
31. Mathieu, J., Maynard, M.T., Rapp, T., Gilson, L.: Team effectiveness 1997-2007: A review of recent advancements and a glimpse into the future. J. Manage. 34, 410–476 (2008).
32. Maus, H., Jilek, C., Schwarz, S.: Remembering and forgetting for personal preservation. In: Personal Multimedia Preservation: Remembering or Forgetting Images and Video. pp. 233–277. Springer (2018).

33. Siebers, M., Schmid, U., Göbel, K., Niessen, C.: A Psychonic Approach to the Design of a Cognitive Companion Supporting Intentional Forgetting. In: 6. Workshop Kognitive Systeme: Mensch, Teams, Systeme und Automaten (2017).
34. Beierle, C., Kern-Isberner, G.: Methoden wissensbasierter Systeme. Springer (2003).
35. Lang, J.W.B., Bliese, P.D.: General mental ability and two types of adaptation to unforeseen change: Applying discontinuous growth models to the task-change paradigm. J. Appl. Psychol. 94, 411 (2009).
36. LePine, J.A., Colquitt, J.A., Erez, A.: Adaptability to changing task contexts: Effects of general cognitive ability, conscientiousness, and openness to experience. Pers. Psychol. 53, 563–593 (2000).
37. Doomen, J.: Information Inflation. J. Infor. Ethics. 18, 10 (2009).
38. Easterby-Smith, M., Lyles, M.A.: In praise of organizational forgetting. J. Manag. Inq. 20, 311–316 (2011).
39. Eppler, M.J., Mengis, J.: The concept of information overload: A review of literature from organization science, accounting, marketing, MIS, and related disciplines. Inf. Soc. 20, 325–344 (2004).
40. Bjork, R.A.: Positive forgetting: The noninterference of items intentionally forgotten. (1970).
41. Becker, J., Beverungen, D., Knackstedt, R., Müller, O.: Pricing of Value Bundles-A Multi-Perspective Decision Support Approach. Enterp. Model. Inf. Syst. Archit. Int. J. Vol. 6, Nr. 2. (2011).
42. Meeßen, S.M., Thielsch, M.T., Hertel, G.: Trust in management information systems (MIS): A theoretical model. Manuscr. Submitt. Publ. (2018).
43. Thielsch, M.T., Meeßen, S.M., Hertel, G.: Trust and distrust in information systems at the workplace. PeerJ. 6, e5483 (2018).
44. Hertel, G., Meeßen, S.M., Riehle, D., Thielsch, M.T., Nohe, C., Becker, J.: Directed forgetting in organizations: The positive effects of decision support systems on mental resources and well-being. Manuscr. Submitt. Publ. (2018).
45. Daft, R.L., Weick, K.E.: Toward a model of organizations as interpretation systems. Acad. Manag. Rev. 9, 284–295 (1984).
46. Walsh, J.P., Ungson, G.R.: Organizational memory. Acad. Manag. Rev. 16, 57–91 (1991).
47. Gersick, C.J.G., Hackman, J.R.: Habitual routines in task-performing groups. Organ. Behav. Hum. Decis. Process. 47, 65–97 (1990).
48. Pentland, B.T., Hærem, T.: Organizational routines as patterns of action: Implications for organizational behavior. Annu. Rev. Organ. Psychol. Organ. Behav. 2, 465–487 (2015).
49. Holan, P.M. de, Phillips, N.: Remembrance of things past? The dynamics of organizational forgetting. Manage. Sci. 50, 1603–1613 (2004).
50. de Holan, P.M., Phillips, N., Lawrence, T.B.: Managing organizational forgetting. MIT Sloan Manag. Rev. 45, 45 (2004).
51. Miller, K.D., Pentland, B.T., Choi, S.: Dynamics of performing and remembering organizational routines. J. Manag. Stud. 49, 1536–1558 (2012).
52. Fiol, C.M., O'Connor, E.J.: Unlearning established organizational routines - Part I. Learn. Organ. 24, 13–29 (2017).

53. Cohen, M.D., Bacdayan, P.: Organizational routines are stored as procedural memory: Evidence from a laboratory study. Organ. Sci. 5, 554–568 (1994).
54. Gronlund, S.D., Kimball, D.R.: Remembering and Forgetting: From the Laboratory Looking Out. In: Individual and Team Skill Decay. pp. 38–76. Routledge (2013).
55. Nairne, J.S., Pandeirada, J.N.S.: Forgetting. In: Roediger, H.L. (ed.) Learning and Memory: A Comprehensive Reference. pp. 179–194. Elsevier, Oxford (2008).
56. Kluge, A., Schüffler, A.S., Thim, C., Vladova, G., Gronau, N.: Putting Intentional Organisational Forgetting to an Empirical Test: Using Experimental Designs to Measure Forgetting of Organisational Routines. In: Proceedings of the IFKAD Conference. pp. 245–267. , Technical University of Delft (2018).
57. Oinas-Kukkonen, H., Harjumaa, M.: Persuasive systems design: key issues, process model and system features. In: Routledge Handbook of Policy Design. pp. 105–123. Routledge (2018).
58. Carden, L., Wood, W.: Habit formation and change. Curr. Opin. Behav. Sci. 20, 117–122 (2018).
59. Wood, W., Rünger, D.: Psychology of habit. Annu. Rev. Psychol. 67, 289–314 (2016).
60. Adriaanse, M.A., Gollwitzer, P.M., De Ridder, D.T.D., De Wit, J.B.F., Kroese, F.M.: Breaking habits with implementation intentions: A test of underlying processes. Personal. Soc. Psychol. Bull. 37, 502–513 (2011).
61. Gollwitzer, P.M.: Implementation intentions: strong effects of simple plans. Am. Psychol. 54, 493 (1999).
62. Quinn, J.M., Pascoe, A., Wood, W., Neal, D.T.: Can't control yourself? Monitor those bad habits. Personal. Soc. Psychol. Bull. 36, 499–511 (2010).
63. Gardner, B.: A review and analysis of the use of 'habit'in understanding, predicting and influencing health-related behaviour. Health Psychol. Rev. 9, 277–295 (2015).
64. Breuer, C., Hüffmeier, J., Hertel, G.: Does trust matter more in virtual teams? A meta-analysis of trust and team effectiveness considering virtuality and documentation as moderators. J. Appl. Psychol. 101, 1151 (2016).
65. Endsley, M.R.: Designing for situation awareness: An approach to user-centered design. CRC press (2016).