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When computers take the lead: The automation of leadership

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A B S T R A C T

The importance of technology in the workplace has been, and continues to be, on an upward trajectory. Technological progress allows more and more functions once performed by humans to be automated. Theoretical conceptualizations in human-computer interaction (HCI) covered the evolution of computers from 'tools' to 'partners' in interaction with humans at work. However, nowadays computers have also begun to take over leadership functions, guiding and commanding human workers. We argue that conceptual coverage is in danger of falling short of this development and the implied profound change in hierarchy.

To close this gap, we propose the paradigm of 'computers as leaders' and call for a scientific discourse of computers performing leadership functions. Building on research in HCI and human-human leadership, we suggest a definition of computer-human leadership and a respective structural model, entangling interaction roles of the different human and computer agents involved. Moreover, we discuss criteria for evaluating automated leadership systems and questions of function allocation, before we bring our propositions together in a theoretical model depicting how humans come to accept and follow a computer leader. Finally, we discuss implications of the proposed paradigm and call for awareness of ethical issues.

> "The computer makes no decisions; it only carries out orders. It's a total moron"
>
> Drucker, P. (1967). The Manager and the Moron. McKinsey Quarterly, 1967

1. Introduction

Technology has become an integral part of our jobs and workplaces, with ever more functions - once performed by humans - becoming automated (Ghislieri, Molino, & Cortese, 2018; Hancock, 2014). Were computers[1] in clerical work once mainly used by human workers for simple calculations and typewriting, nowadays, we find sophisticated decision-support systems that assist human workers with analyses and interpretations of complex data, e.g., stock rates, business development, medical data, epidemiologic or demographic trends (Brynjolfsson & McAfee, 2014; Haenssle et al., 2018; Lisboa & Taktak, 2006; Richards, Yeoh, Chong, & Popovič, 2017). This technological advancement is reflected in the paradigms used in HCI (human-computer interaction): As long as computers and machines 'only' performed tasks on the orders of their human users or operators, clear 'master'-'slave' or 'user'-'tool' paradigms were appropriate to model their interaction. With technological progress, more sophisticated computers and machines were able to perform and thus were allocated increasingly complex tasks, so that they have become modelled and perceived more and more as 'partners' or 'teammates' than as 'tools' (e.g., Christoffersen & Woods, 2002; Madhavan & Wiegmann, 2007; Wynne & Lyons, 2018). In these constellations, humans and computers are no longer in a 'master'-'slave' relationship but on a more equal level of hierarchy (e.g., Jarrassé, Sanguineti, & Burdet, 2014). Thus, with technological progress, an additional paradigmatic conception of computers as interaction entities evolved, one in which computers moved up the hierarchy from being perceived in a subordinate role ('tool') to a more equal role ('partner' or 'teammate').

Yet, technological progress has not stopped and has brought about and will increasingly bring about situations in which computers do not only assist humans with specific allocated tasks, but in which computers will lead humans, i.e., guide them through their working day, allocate tasks, set the working pace, etc.. In these interactions computers are actually the source of decision-making rather than mere decision-

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[1] Throughout this article, we use the term 'computer' to denote a digital tool representing a generic technological agent. With this generic term we do not mean one specific hardware device (e.g., personal desktop computer) but software implemented in different forms of physical appearances (e.g., robots, desktop computers, mobile devices, etc.).

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support for human workers. One specific example for an existing application that performs leadership functions is the system 'iCEO'. This application represents an automated system that takes over the management of complex work (e.g., compiling a research report for a client) by dividing it into smaller tasks, which it then assigns to internal and external workers using multiple software platforms (such as oDesk and Uber), and email or text messaging (Fidler, 2015). The system autonomously hires and compensates workers, defines and allocates tasks, gives feedback and controls the results. Another example, and probably one of the most advanced automated management systems to date, is used by Uber Technologies Inc.. This system processes customer pickup requests and assigns these to drivers based on their availability and location. It then monitors drivers' accepted requests and evaluates customers' ratings. Based on the accumulated information, the system provides feedback to the drivers about improving customers' driving experiences but also adjusts driving fares or suspends drivers for low acceptance rates or negative customer ratings. Moreover, the system queries the drivers regarding their prospective working days and hours and incentivizes them to work or not at specific dates in order to optimize the supply of available drivers in each region for the forecasted demand at all times (Lee, Kusbit, Metsky, & Dabbish, 2015; Simonite, 2015). The Uber system thus automates several leadership functions such as task allocation, shift planning, performance feedback and compensation.

Taking these examples into account and anticipating further technological progress, we argue that it is necessary to add another paradigm to model interactions between humans and computers, one that conceptualizes computers again one hierarchy level higher: the paradigm of 'computers as leaders'. We argue that current and future technological developments make such inverted hierarchical relations possible (i.e., relations, in which humans perform tasks on the command of computers) and that such inverted hierarchical relations between humans and computers have so far not been covered in HCI research.

We are aware that the idea of humans taking orders from computers is at odds with most people's experiences and expectations and challenges firmly held axioms in HCI. Principles of human-centered automation (Billings, 1991, 1996) and interaction design (e.g., Nielsen, 1994; Shneiderman & Plaisant, 2004) stress the importance of the operator being in command and the user being in full control at all times. Acknowledging these axioms, we nevertheless deem it necessary to explore the paradigm of 'computers as leaders' to keep pace with current technological developments and applications (see also Geiskkovitch, Cormier, Seo, & Young, 2016).

There are three reasons why we regard it important to enlarge the set of paradigms used to model human-computer interaction to adequately reflect hierarchical relations in the workplace: *Firstly,* as Jamieson & Skraaning, (2018) emphasize, HCI-paradigms (or interaction metaphors as they call it) establish a likeness between a specific human-computer constellation and an analogous familiar pattern (e.g., a desktop workspace). These paradigms guide researchers' and designers' thinking away from seemingly unsuitable and toward seemingly suitable ideas (e.g., physical folders and files) in the analogous situation (for metaphors and representations in HCI, see also Benyon & Imaz, 1999). Jamieson & Skraaning, (2018) argue that the 'computers as tools' paradigm is no longer appropriate for modern human-computer interaction and misguides researchers and designers in their approaches. While they advocate to endorse the 'computers as teammates' paradigm, we go a step further and call for endorsing the 'computers as leaders' paradigm to appropriately reflect technological advancement. By this, we do not imply that the paradigms of 'computers as tools' and 'computers as partners' become obsolete. There will be computers that function as tools of human work, just as there will be computers assuming the role of a team-member in human-computer teams. But we argue that with technological progress there will also be an increasing number of computers that perform leadership functions over humans, which calls for an enlargement of our paradigmatic conceptions of human computer interactions at work. *Secondly,* we regard it important that research conceptions keep pace with technological advancement to fulfill the societal responsibility of science (Ghislieri et al., 2018). The scientific discourse should objectively broach the risks and opportunities associated with computers in leadership positions. Indeed, this should be independent of commercial providers of products and applications and should be addressed before such systems are widely implemented in practice. And *thirdly*, the profound change in hierarchy (humans as subordinates and not as users or consumers of technology; e.g., Lee, 2018) requires a re-evaluation of existing knowledge and models in HCI regarding their suitability for computer-human leadership (CH leadership) constellations. Only the understanding of the specific interaction dynamics in CH leadership enables researchers to delineate recommendations to develop automated leadership systems that satisfy both organizational interests regarding system performance and human subordinates' interests regarding job-related satisfaction, motivation, and well-being.

In the following sections, we will explore the appropriateness of the paradigm 'computers as leaders', propose a working definition, define the involved interaction roles in a structural model, and reflect upon evaluative criteria for successful CH leadership and related questions of function allocation. We subsequently discuss the pivotal role of acceptance of computers as leaders and draw on the human-human leadership (HH leadership) concept of legitimacy. We bring our propositions together in a theoretical model (leadership-technology acceptance model) suggesting influencing factors and consequences of CH leadership as a basis for future research and future developments of automated management systems. We conclude by discussing research implications of the proposed paradigm 'computers as leaders' and possible directions of future technological developments relevant for CH leadership applications and finally call for an awareness of ethical issues when researching, designing, and applying CH leadership.

2. Computers as leaders - existing interaction models

Two obvious research domains to draw from for developing models for the automation of leadership or CH leadership are 1) leadership research and 2) HCI and automation research. However, as we will outline in the following section, on the one hand, leadership research has so far almost exclusively dealt with human-human interaction (HHI), i.e., leadership of human leaders over human subordinates. While on the other hand, existing models in automation and HCI are based on the axiom that humans should always be in command of computers and do not provide for the possibility of computers leading humans. Based on the literature of both domains, we will demonstrate how a synergistic approach extending HCI and automation models with models from leadership research can result in new integrative models that can depict and explain interaction dynamics in CH leadership.

2.1. Leadership models and their applicability to CH leadership

Leadership research has a long tradition of examining how individuals can be led best (e.g., Barnard, 1938) and has meticulously examined the complex interaction processes between human leaders and human subordinates (e.g., Avolio, Walumbwa, & Weber, 2009; DeRue, Nahrgang, Wellman, & Humphrey, 2011). The by far most commonly researched form of HH leadership indeed involves hierarchical interactions between a formal human leader and one or more human subordinates (Dinh et al., 2014). However, formal top-down hierarchical relationships are not a defining factor for leadership research. Leadership researchers also examine informal leadership (Pescosolido, 2001), lateral and upward leadership (Yukl & Falbe, 1990), or shared leadership (D. Wang, Waldman, & Zhang, 2014). Similarly, human agents are not a mandatory component for leadership to occur. As early as the 1970ies, Kerr and Jermier (1978) proposed in their 'Substitutes for Leadership Theory', that aspects of leadership by human agents can be substituted in certain instances, for example by tasks that are unambiguous or tasks that provide subordinates with feedback as to how well the task is being done. Thus, leadership research provides some interesting starting points regarding new conceptualizations of leader-subordinate interactions.

However, when it comes to technology in the workplace, leadership research has so far taken a rather narrow perspective. Under the terms of *e-leadership* (Avolio, Kahai, & Dodge, 2000), *virtual leadership* (Schmidt, 2014), or *computer-mediated leadership* (O. Fischer & Manstead, 2004) the influence of technology use on traditional leadership and team processes between human leaders and human subordinates has been examined. However, in these approaches, computers and technology are conceptualized as mere communication media and not as *active agents* in leadership and team processes. Up to now, leadership research has not yet accounted for situations in which computer agents take on leader positions and lead human subordinates.

The neighboring field of management research (that is compared to leadership research more concerned with the macro-perspective of managing organizations and to a lesser extent with aspects of directly leading specific subordinates) has explored managers' technology use beyond mere communication means. Here, research has examined the extent and results of managers' use of technology supporting them in their daily tasks (e.g., Vlahos, Ferratt, & Knoepfle, 2000), in particular business intelligence systems (depending on their focus also called computer-based information systems, decision-support systems, management information systems, executive information systems, etc.).

According to Olszak (2016), business intelligence is an umbrella term to describe "technologies, applications, and processes for gathering, storing, accessing, and analyzing data to help users make better decisions" (p. 107). Davenport (2010) differentiates three levels on which business intelligence can be implemented to help organizational decision-makers taking better and faster decisions: a) loosely coupled information and decisions (the most commonly used implementation, where information is made broadly accessible to human analysts and decision-makers for application to decisions), b) structured human decision environments (where structured environments are created for specific decision, so that predetermined information is made available to human decision-makers when making this specific decisions), and c) automated decision-making (where human experts design automated decision-making system that decide specific recurring decisions, e.g., automated pricing decisions in e-commerce, and humans usually come into play only to handle exceptions). Hence, also in the research area of business intelligence, computers are usually conceptualized as 'tools' or 'teammates', underlining their support function for human managers and leaders and are not considered as agents managing or leading humans.

Nevertheless, insights from HH leadership and management research might be informative for the study of CH leadership. As Nass and colleagues (e.g., Nass, Steuer, & Tauber, 1994) showed in their work on the '*computers are social actors*'-paradigm, humans treat computers and other technologies as if they were independent entities rather than as manifestations of human construction and programming (Sundar & Nass, 2000) and respond to them as if they were human. For example, humans use stereotypical social categories and social behaviors, such as politeness and reciprocity, in their interactions with computers (Nass & Moon, 2000). Based on that, we propose that it might be possible that human subordinates interpret computers performing leadership functions as independent entities and respond to them with social cognitions and behavior similar to what HH leadership research examines regarding social cognitions and behavior towards human leaders. This would allow scholars to draw from the established research in HH leadership and transfer and adapt relevant variables (e.g., trust in leaders, Dirks & Ferrin, 2002; legitimacy attributed to leaders, Tost, 2011; or followership, Uhl-Bien, Riggio, Lowe, & Carsten, 2014) to the study of CH leadership.

2.2. HCI and automation models and their applicability to CH leadership

Assessing the applicability of models in HCI to CH leadership, it is helpful to break automated leadership down into the different interactions of the different agents involved and inspect them separately. As a first step in the automation of leadership, human agents delegate (parts of) their leadership functions to computers. Such interactions between humans and computers have indeed been described and analyzed in common HCI models, for example in the model of types and levels of automation (Parasuraman, Sheridan, & Wickens, 2000). However, the basic idea of such models is that computers then manipulate inanimate objects, like data, materials or products. In contrast, in CH leadership, the computer takes over (parts of) human leaders' interactions with their human subordinates. This latter kind of interaction has not yet been covered in HCI models. For example, Scholtz (2003) based on earlier work of Sheridan and Verplank (1978) differentiates five interaction roles that humans can assume when interacting with a computer agent: (1) supervisor, (2) operator, (3) teammate, (4) bystander, and (5) mechanic. Yanco and Drury (2004) concur with these five interaction roles and integrate them in a more comprehensive taxonomy that also features different constellations of multiple human and multiple computer agents. Yet so far, no model known to us considers interactions of computer agents leading one or more human agents.

One could argue that the question of who leads whom might be a purely theoretical interest and of little practical relevance in HCI. However, research shows that hierarchical relations do play a central role: Hierarchies are a ubiquitous form of human social organization that has functional benefits (e.g., facilitating group performance) but more importantly they serve humans' psychological need to perceive their existence and surroundings as structured, clear, ordered, and predictable (Friesen, Kay, Eibach, & Galinsky, 2014). Work organizations have particularly strict hierarchical structures: Top-level managers lead middle managers who, in turn, lead team leaders who, in turn, lead groups of individual employees etc. with the number of management levels depending on the size of the organization. Moreover, interactions in work organizations are not limited to one-to-one interactions. Leadership functions are often directed at groups of subordinates. Taken together, we did not find models in neither HCI and automation research nor HH leadership research that would be suitable to depict CH leadership relations in organization. That is models providing for 1) hierarchical relationships between computers and humans in which computers take the lead, and, linked to that 2) one (computer)-to-many (subordinates)-relationships.

Based on our review of models in both HCI and automation research and leadership research, we deem it necessary to synergistically combine models and insights from both research domains to provide for the complex interactions between computer agents and human agents in CH leadership constellations. It should be noted, however, that we do not assume that these are always transferable exactly one to one from one domain to the other. As Jamieson & Skraaning, (under review) put forward in the context of human-computer teamwork, it does not always make sense to transfer knowledge from human-human teamwork to human-computer teams. As a starting point and basis for further theory development in the domain of CH leadership however, we consider it as being beneficial and constructive to take advantage from theories and knowledge in both areas.

3. Conceptualizing CH leadership

In order to theoretically model and empirically explore the interactions between computers and humans in the automation of leadership, we suggest 1) a structural model that describes the various interaction roles of the different human and computer agents involved in CH leadership constellations in organizations, 2) a working definition for CH leadership, that is computer leaders commanding human

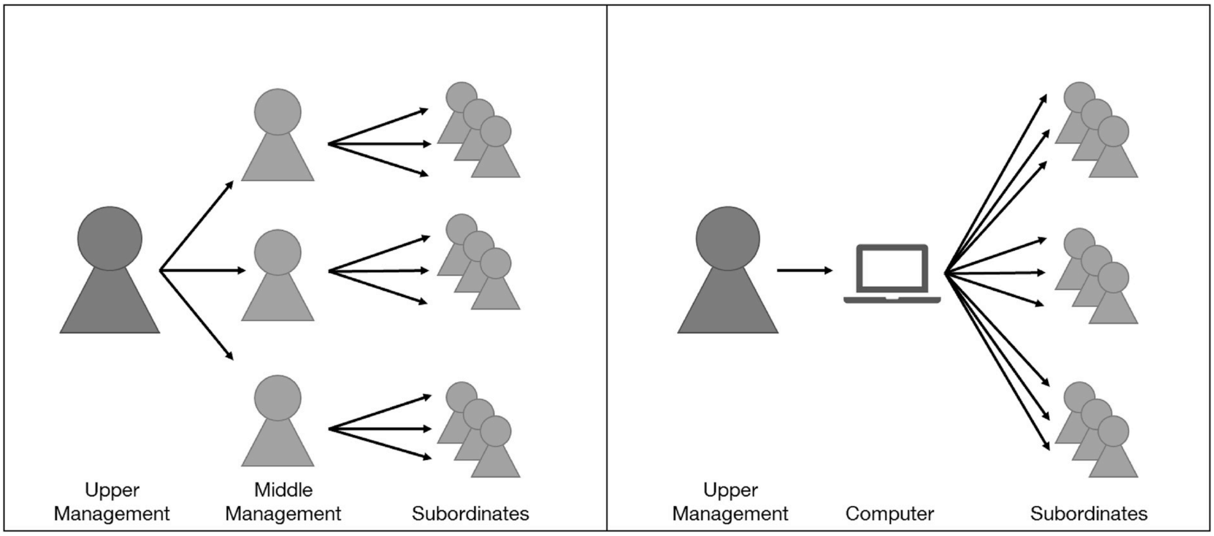


Fig. 1. Hierarchical leadership relations in all human systems vs. human-computer systems.

subordinates, and 3) a set of evaluative criteria for successful automation of leadership.

3.1. Structural model of CH leadership in organizations

As a first step, we find it helpful to depict the different interaction roles of human and computer agents involved in CH leadership in a structural model. For this purpose, we suggest to add the interaction role of 'subordinate' to the five interaction roles that humans can assume when interacting with a computer agent according to Scholtz (2003) and Yanco and Drury (2004). For the schematic representation of hierarchical relations in organizations, we suggest a three-level structural model depicting leader-subordinate relationships in HH as well as CH leadership constellations (see Fig. 1).

At the top of the hierarchy, a human higher-level manager defines goals, methods and principles of conduct. In traditional HH organizations, several middle managers lead their subordinates according to the goals and conditions defined by the higher-level management. In CH leadership constellations, these leadership functions of middle managers are allocated to a computer. This automation of leadership functions results in the substitution (or supplementation) of middle managers in the organizational hierarchy and consequently in computers leading human subordinates. This implies a hierarchical relationship between computers and humans in the opposite direction to existing axioms and models in HCI and automation research. In our structural model, human or computer agents in the middle manager position hold both 'subordinate' (to their higher-level leaders) and 'leader' (to their subordinates) interaction roles. 'Subordinates' of the same leader are 'teammates' in interactions with each other.

3.2. Definition of CH leadership

The new and hitherto theoretically uncovered aspect in the above structural model is the hierarchical relationship between a computer leader and human subordinates. To clearly distinguish CH leadership interactions from other interactions between computers and humans, we suggest a working definition of CH leadership adapted from HH leadership. Here, we deliberately decided to base our model on a functional definition of leadership, to be able to examine the specific way in which a computer leader exerts this influence as well as resultant subordinate reactions independently. Some leadership definitions, for example by Schein (1992) ("the ability to step outside the culture […] to start evolutionary change processes that are more adaptive", p. 2) or Drath and Palus (1994) ("the process of making sense of what people are doing together so that people will understand and be committed", p. 4), tie 'leadership' to specific leadership styles (e.g., charismatic or visionary leadership) or specific outcomes (e.g., subordinates' commitment or satisfaction). In contrast, Yukl (2013, p. 18) defines leadership rather functionally as "*a process whereby intentional influence is exerted by one person over other people to guide, structure, and facilitate activities and relationships in a group or organization*", providing a more suitable frame for our research focus.

We adapted the above presented definition by Yukl (2013) to CH leadership with only small adjustments: *CH leadership describes a process whereby purposeful influence is exerted by a computer agent over human agents to guide, structure, and facilitate activities and relationships in a group or organization*. The definition details which behaviors of an agent in a leadership position are considered leadership behavior and which are not. As leaders are appointed to their position by organizations to facilitate organizational goal attainment, the definition of leadership according to Yukl (2013) concentrates on leaders' intentional *behaviors* (or in our adoption 'purposeful behaviors', as we do not infer intention in computers), aimed at influencing subordinates to contribute to organizational goals[2]. To do so, leaders perform various *leadership functions* to guide, structure and facilitate subordinates' contribution to organizational goal attainment, e.g., setting goals and priorities, planning and coordinating material and personnel resources, obtaining, monitoring, and motivating subordinates. These functions can be enacted by leaders in many different ways, which are detailed and examined in research on *leadership styles* (e.g., Hoch, Bommer, Dulebohn, & Wu, 2016; 2018).

However, before examining the specifics of CH leadership styles, other questions regarding CH leadership must be discussed. This refers to an analysis of which leadership functions can be automated, i.e., executed by computer leaders, and what kind of outcomes and criteria should be taken into consideration when evaluating automated leadership systems.

3.3. Evaluative criteria for CH leadership

In HH leadership research both objective and subjective criteria are used to determine the quality of leadership: Objective criteria are subordinates' quantitative and qualitative performance, turnover, accidents, etc., while examples for subjective criteria are subordinates'

[2] In reverse, this means that any other behavior of these agents does not fall under the definition of HH or CH leadership.

Table 1
Objective and subjective criteria of successful CH leadership.

Referent	Objective Criteria	Subjective Criteria
Human Higher-Level Leaders (Parasuraman et al., 2000; Sauer & Chavaillaz, 2018)	• system performance (e.g., primary and secondary task performance) • automation-related errors (e.g., omissions and commissions) • automation management behavior such as the actual use of automation and complacency, which represents the extent to which automation verification behavior is not sufficiently shown by operators	• trust in the automated system • self-confidence in task completion • workload • automation state awareness
Human Subordinates (e.g., Judge et al., 2004)	• subordinates' quantitative and qualitative performance • subordinates' turnover • subordinates' accidents	• subordinates' satisfaction with the job and with the leader • subordinates' motivation • subordinates' well-being
Automated Management System (Parasuraman, 2000; Parasuraman et al., 2000)	• automation reliability • costs of decision/action outcome • ease of system integration • implementation costs • liability	

satisfaction with the job and with the leader, motivation, and well-being (e.g., Judge, Piccolo, & Ilies, 2004). These criteria can well be transferred to CH leadership: Low turnover rates, few accidents and high performance can be suitable objective indicators of successful CH leadership. Likewise, high satisfaction, motivation and well-being of subordinates can be considered relevant subjective indicators of successful computer leadership. While these criteria from the HH leadership domain can be considered useful and transferable to CH leadership, especially to apply with the human subordinates, the additional consideration of criteria from the domain of HCI and automation might enable a more comprehensive assessment of the quality of CH leadership.

The international standard ISO 6385:2016 lists the optimization of human well-being and overall system performance as overarching design objectives for the interaction between human workers and work systems (International Organization for Standardization, 2016). If we inspect more specific accounts of evaluative criteria in HCI and automation research, it becomes apparent, that these have defined for 'operator'-'tool'-interactions between humans and automated systems. Hence, they focus on criteria pertaining to automated systems as tools and humans as operators. For example, Parasuraman et al. (2000) differentiate primary evaluative criteria which are human performance consequences (i.e., operators' mental workload, situation awareness, complacency, and skill degradation) and secondary evaluative criteria which are system-related variables (e.g., system reliability, ease of integration, or implementation costs). Sauer and Chavaillaz (2018) give an updated account of typical human performance criteria for human-automation interaction and differentiate between objective and subjective criteria. Objective criteria include operators' automation management behavior (e.g., use of automation, complacency, etc.), automation-related errors (e.g., errors of omission or commission) and primary and secondary task performance. As subjective criteria they list operators' trust in the automated system, self-confidence in task completion, workload, and automation state awareness.

We argue that a synergistic combination of the evaluative criteria suggested in the different research domains (i.e., leadership research on the one hand and HCI and automation research on the other hand) yields the most comprehensive assessment of CH leadership and covers all three levels proposed in our structural model of CH leadership (see Table 1). The objective and subjective criteria suggested to evaluate performance consequences of operators (Parasuraman et al., 2000; Sauer & Chavaillaz, 2018) cover the perspective of higher-level leaders that delegate their leadership functions to the automated management system. The system-related evaluative criteria (Parasuraman, 2000; Parasuraman et al., 2000) cover the utility of the automated management system, and the objective and subjective criteria from leadership research (Judge et al., 2004) cover the perspective of the human subordinates.

Such a comprehensive set of evaluative criteria allows the comparison of the quality of CH leadership constellations with different characteristics (e.g., different leadership styles or differences in the usability of automated leadership systems) without losing sight of the interests of the different stakeholders involved. Taking the evaluative criteria into account, the first question we want to explore is that of function allocation, or put differently, the question of which leadership functions could be automated, and which should continue to be performed by human leaders.

3.4. Function allocation between human and computer leaders

Function allocation is a central topic in HCI research (Hollnagel & Bye, 2000) addressing the question of whether a particular function should be accomplished by a person, technology (hardware or software), or some mix of person and technology. Various principles of function allocation have been discussed so far. An often used but criticized (e.g., Hancock, 2014) principle of function allocation is the 'left-over' principle. This states that everything that can be automated, should be automated, and that humans should only perform those functions that have not been, or cannot be, automated due to technical or economic reasons.

An alternative principle in function allocation is the compensatory principle, which states that functions are allocated based on predetermined strengths and weaknesses of humans and computers (Bye, Hollnagel, & Brendeford, 1999). A renowned example of this approach is the historic Fitts List (Fitts, 1951), which structured generic recommendations regarding function allocation between human and machine agents. In 1951, Fitts contended that humans surpassed - the then current - machines regarding 1) detection, 2) perception, 3) improvisation, 4) long-term storage and retrieval of information, 5) inductive reasoning, and 6) judgement. Conversely, he suggested that machines surpassed humans in respect to 7) speed and power, 8) replication, 9) short-term storage and retrieval of information, 10) deduction and computation, and 11) simultaneous operations. Since all recommendations refer to the current developmental stage of computers, there is a need to re-evaluate them with technological progress.

About 50 years later, de Winter and Hancock (2015) conducted two evaluations of humans' opinions regarding the 11 areas specified by Fitts (1951) and the question of whether humans surpass machines and vice versa. Results showed that the majority of participants thought that humans surpass machines regarding improvisation, induction and judgment, and that machines surpass humans in the remaining 8 areas. Applying the updated relative strengths of humans and computer by de Winter and Hancock (2015) to the automation of leadership, one could infer that computers could be allocated all those leadership functions that for instance do not require creativity, induction, or improvisation. Hence, leadership functions that for example involve collecting standardized information and evaluating it against predetermined criteria, like monitoring of and giving feedback on quantitatively measurable task performance, could be satisfactorily performed by automated management systems. Conversely, giving feedback on task performance that is not standardized, not quantitatively measurable, or that is affected by unprecedented circumstances could not by satisfactorily performed by automated management systems – based on the updated list of relative strengths of humans and computer by de Winter and Hancock (2015). In a similar vein, Derrick and Elson (2018) suggest that leadership functions such as goal setting, performance monitoring, and communicating performance consequences could be automated. However, a more systematic approach based on systematic analyses of leadership functions enables more valid conclusions than arbitrary collections of examples.

Management and leadership researchers have also made initial attempts to address the question of possible advantages and disadvantages of computers taking over leadership functions in future organizations (Avolio, Sosik, Kahai, & Baker, 2014; Chamorro-Premuzic & Ahmetoglu, 2016; Dewhurst & Willmott, 2014; Parry, Cohen, & Bhattacharya, 2016). While this discussion remains on a rather general level, possible pros and cons of computers as leaders are mainly argued regarding two aspects: 1) information processing and organizational decision-making and 2) emotional and social issues at work.

Regarding the advantages of computer leaders in information processing and decision-making (factor 1), it has been speculated that they will soon outperform human leaders in the quality of organizational decision-making. This is due their superior information processing capacity (Chamorro-Premuzic & Ahmetoglu, 2016), their superior and, most importantly, unbiased ability to recognize latent patterns in incomplete data sets (Parry et al., 2016), the absence of fatigue and similar human weaknesses (Avolio et al., 2014), and finally the absence of self-interests (Parry et al., 2016). The latter is expected to prevent problems arising from a misalignment of the interests of managers and the organization (e.g., due to corruption or 'principal-agent-problems', i.e., managers putting their self-interests before the organization's interest; Wesche, May, Peus, & Frey, 2010). With regard to emotional and social issues at work (factor 2), computer leaders are considered to have specific advantages over human leaders when it comes to the direct interaction with human subordinates: Computer leaders are not influenced by emotions, which may reduce conflicts (e.g., as computers do not reciprocate negative emotions or retaliate) and enable objective feedback (e.g., as computers are not conflict-averse or jealous; Chamorro-Premuzic & Ahmetoglu, 2016).

Naturally, drawbacks of computers taking over leadership functions have also been addressed. Regarding information processing and organizational decision-making (factor 1), one has to bear in mind that computers develop their algorithms on existing data and might therefore extrapolate inherent undesirable trends and biases (Chamorro-Premuzic & Ahmetoglu, 2016). For example, if a personnel selection algorithm is trained on a dataset of current incumbents of higher-level job positions, in which females are underrepresented, its resultant predictions would perpetuate favoring males if developers do not qualify the use of specific characteristics for prediction (e.g., Kilbertus et al., 2018; Speicher et al., 2018). Moreover, computers might lack the ability for true and spontaneous creativity ('unanticipated emergence') and innovation (Avolio et al., 2014; Chamorro-Premuzic & Ahmetoglu, 2016; Parry et al., 2016). They might lack adequate ethical, cultural and legal considerations (Avolio et al., 2014) if not programmed otherwise, and might tend to overemphasize objective, computable criteria (quantitative targets) and underemphasize subjective, largely non-computable criteria (qualitative values) (Parry et al., 2016).

The most profound drawback of computer leaders according to Chamorro-Premuzic and Ahmetoglu (2016) lies in factor 2. This is because computers do not have emotions and are not (yet) able to accurately detect human emotions. Therefore, human subordinates' needs for social contact might not be fulfilled as they might miss true human empathy, recognition and appreciation. However, taking into account the advancements made in the domains of affective computing (Picard, 1997) and artificial emotional intelligence (Krakovsky, 2018) by adopting techniques such as deep learning (Rouast, Adam, & Chiong, 2019, early access) and multimodal data fusion (D'Mello & Kory, 2015), it can be assumed that it will not be long before computers are able to recognize and reproduce affective states – perhaps even more precise and appropriate than humans.

Again, these considerations from management and leadership researchers about advantages and disadvantages of computer leaders are an interesting starting point, but very generic. They do not allow concrete and systematic inferences for the automation of different leadership functions. To be able to draw such systematic inferences, we propose bringing together the insights of HCI and HH leadership research in a systematic way. Specifically, we suggest to combine the compensatory principle (e.g., Fitts, 1951) with established taxonomies in HH leadership research, detailing the leadership functions human leaders usually perform, in order to systematically determine which of these functions can be delegated to computers. One renowned taxonomy of leadership functions has been proposed by Fleishman et al. (1991). Based on a systematic review and integration of previous taxonomic efforts, these authors derived 13 generic leadership functions, clustered in four superordinate categories. The categories include a) search and structuring of information, b) use of the information for problem solving, c) managing personnel resources and d) managing material resources (see Table 2 for behavioral descriptions of the leadership functions).

Based on the reviewed discussion of strengths and weaknesses of humans and computers in general (e.g., de Winter & Hancock, 2015) and of strengths and weaknesses of computers as leaders in particular (Avolio et al., 2014; Chamorro-Premuzic & Ahmetoglu, 2016; Dewhurst & Willmott, 2014; Parry et al., 2016), the 13 leadership functions can be evaluated with respect to their suitability to be performed by a computer leader. However, a detailed and profound analysis of function allocation in the context of leadership automation would exceed the scope of this work. Future research needs to address the question about which functions of a human leader can be and should be automated and which not. From a technological point of view, it can be assumed that a large part of the leadership functions presented in Table 2 is transferable to a computer leader – in particular taking into account the ongoing high pace of advancement in the domains of artificial intelligence and computing power. Whether human subordinates however would enjoy working and would perform well in an organization deploying a computer leader that takes over all of the 13 leadership functions might depend upon various factors such as individual subjective norms and attitudes, the subjective perception of the computer leader as well as the acceptance of the automated system.

4. The importance of acceptance in leadership processes

Equipped with a structural model, a working definition and evaluative criteria of CH leadership, we want to delve deeper into the interaction between computer leaders and human subordinates. Specifically, we want to take a closer look at one necessary condition for CH leadership: the acceptance of the computer leader by human subordinates.

When leadership is influence exerted by one agent over other agents (Yukl, 2013), probably the most important question that HH leadership research tries to answer is how this influence can be exerted over others so that they actually defer to the decisions and rules of the leader. As van Quaquebeke and Eckloff (2013, p. 68) put it:

> "Force, pressure, or manipulation may create a temporary opening [… to subordinates' openness to leader influence], but leadership is only truly sustainable and effective if subordinates voluntarily follow their leaders".

Table 2
Leadership Functions according to Fleishman et al. (1991). (table continued).

Categories	Leadership Functions	Behavioral Descriptions
I. Information Search and Structuring	1) Acquiring Information	Gathering, assimilating, storing raw information from pertinent sources.
	2) Organizing and Evaluating Information	Categorizing and converting raw information into useful knowledge or awareness by carefully considering sources, timeliness, accuracy, relevance, and overall usefulness in respect to relevant goals and organizing structures.
	3) Feedback and Control	Following up on guidance, directives, and actions to learn whether they are understood and implemented at all levels; determining whether the results of your guidance, directives, and actions were what was expected and desired.
II. Information Use in Problem Solving	4) Identifying Needs and Requirements	Being alert to existing or potential problem areas or to possibilities for improving an existing system, method, or status; identifying significant factors or constraints that influence the nature of a problem or the requirements for problem solution.
	5) Planning and Coordinating	Conceiving ways and means to accomplish jobs, goals, and missions with available resources and to solve problems with respect to identifying needs and requirements; consulting with others in order to apprise them of plans and activities and to become knowledgeable as to what they are doing or planning to do; confirming what assistance others can and will provide.
	6) Communicating Information	Transmitting, exchanging, reporting, or passing on information in the form of words, messages, emotions, ideas, or signals by any means such as speaking, writing, facial expression, gestures, automatic data processing, or any combination of these either to individuals or groups.
III. Managing Personnel Resources	7) Obtaining and Allocating Personnel Resources	Requisitioning, processing, classifying, and assigning personnel in accordance with authorizations, qualifications, and needs.
	8) Developing Personnel Resources	Setting standards; fostering promotions, schooling, and professional development for the deserving; teaching individuals things they need to know in order to accomplish assigned tasks or increase their potential value to the organization.
	9) Motivating Personnel Resources	Initiating actions to reward and recognize performance; providing a climate and social conditions capable of facilitating performance; insuring that the needs and values of individuals can be met; exhibiting an interest in and providing support for individuals and their efforts.
	10) Utilizing and Monitoring Personnel Resources	Dividing workloads; assigning responsibilities; observing performances, preparing and maintaining reports, charts, logs, tiles, journals, calendars, records, and checklists as a means of monitoring morale, welfare, performance, and training.
IV. Managing Material Resources	11) Obtaining and Allocating Material Resources	Requisitioning and issuing supplies and equipment; requesting and providing facilities and support; requesting and disbursing funds.
	12) Maintaining Material Resources	Storing, safeguarding, servicing, or repairing supplies and equipment; repairing facilities and vehicles; safeguarding funds and documents.
	13) Utilizing and Monitoring Material Resources	Prescribing how supplies, equipment, facilities, transportation, and funds will be used; preparing and maintaining reports, charts, receipts, logs, files, journals, calendars, checklists, and automatic data records as a means of monitoring the status of supplies, equipment, facilities, transportation, funds, and documents.

Whether individuals voluntarily defer to a leader (i.e., accept him/her as a leader) depends on whether they ascribe legitimacy to him/her, i.e., whether they believe that this leader and his/her leadership is appropriate, proper and just and that he/she 'deserves' to rule (Tyler, 1997, 2006).

HH leadership research has shown that individuals evaluate leader behavior on three dimensions in order to decide whether or not to attribute legitimacy to a specific leader: an instrumental, a relational, and a moral dimension (for a detailed review, see Tost, 2011). As Tost (2011) summarizes, these three dimensions are neither mutually exclusive (leaders may be evaluated on more than one of the three dimensions at the same time) nor non-overlapping (specific observations of leaders' behavior may influence subordinates' evaluations on more than one of the three dimensions). The basic assumption underlying the *instrumental dimension* is that individuals are concerned about the favorability of their outcomes and that hence their attribution of legitimacy to a leader is based on their perception that he/she facilitates their attempts to reach self-defined or internalized goals. Thus, they look for competence, success, effectiveness, or efficiency when evaluating a leader (Tost, 2011; Tyler, 1997). The basic assumption underlying the *relational dimension* is that individuals are concerned about their social identity, social relationships, social status, and resultant feelings about themselves (as member of a group), e.g., self-worth. Thus, when evaluating leaders of their groups, they seek for evidence of fairness, benevolence, and communality as these can have important implications for their social identity (Tost, 2011; Tyler, 1997). Finally, individuals attribute legitimacy to leaders on *moral* grounds, when they perceive them to be consistent with their own moral and ethical values (Tost, 2011), making integrity and ethicality of leaders' decision-making important characteristics to look for.

HH leadership research has identified several leadership styles, i.e., behavioral patterns that leaders adopt to influence their subordinates (e.g., the specific style in which they execute their leadership functions) and has investigated their effects on subordinate well-being and performance. The aforementioned instrumental and relational evaluative dimensions of leader legitimacy (Tost, 2011) correspond to the prominent leadership style theory of transactional and transformational leadership introduced by Burns (1978) and Bass (1985). Transactional leadership describes a leadership style that caters to subordinates' self-interest by establishing a stable and fair exchange-relationship between leader and subordinate (i.e., exchanging rewards for work effort). The transformational leadership style tries to move subordinates beyond immediate self-interests and emphasizes elevated ideals and striving for achievement, self-actualization and the well-being of others, the organization, and society. Transactional and transformational leadership are by no means conceptualized as mutually exclusive behavioral styles, on the contrary, it is expected that every leader displays both in varying degrees (Bass, 1999). The moral evaluative dimension of leader legitimacy described above (Tost, 2011) finds correspondence in leadership styles like ethical leadership (Brown & Treviño, 2006) or authentic leadership (Avolio, Gardner, Walumbwa, Luthans, & May 2004; Peus, Wesche, Streicher, Braun, & Frey, 2012). Meta-analytic research shows that human leaders enacting their leadership functions in these leadership styles (i.e., transformational, transactional, ethical, and authentic) indeed positively impact human subordinates' well-being and performance (Hoch, Bommer, Dulebohn, & Wu, 2018, 2016; Ng & Feldman, 2015; G.; Wang, Oh, Courtright, & Colbert, 2011).

4.1. The importance of acceptance in CH leadership

In CH leadership constellations, acceptance of a computer as a leader might be even more difficult to achieve and even more important than acceptance of a human as a leader in HH leadership constellations because, as stated above, the idea of 'computers leading humans' challenges firmly held axioms and is at odds with (current) human workers' experiences and expectations. Indeed, first studies show that humans regard computers as leaders with skepticism: For example, studies show that humans dislike robot-human dyads in which the robot is more dominant than the human compared to the inverse or human-human control dyads (Li, Ju, & Nass, 2015), that humans perceive human co-leaders more favorable than robotic co-leaders (Gombolay, Gutierrez, Clarke, Sturla, & Shah, 2015), and that they follow orders of a robotic compared to a human leader to a lesser extent (Geiskkovitch et al., 2016). In line with that, in a representative survey, S. Fischer and Petersen (2018) find that 79% of the respondents report feeling uneasy with the general idea that algorithms make decisions about them and increasingly prefer human over algorithmic decision-making the more that decision is 'personal' (e.g., personnel selection or criminal prognoses vs. optimization of space utilization in storages or auto-correction in text processing).

This widespread skepticism and unease regarding computer leadership might be influenced by personal experiences with computer leadership (or a lack of these), cultural norms, and probably the 'zeitgeist'. But because acceptance is such a crucial factor for the success of CH leadership – a computer cannot perform leadership functions effectively if human subordinates refuse to follow and instead try to circumvent the systems and turn to a higher-level human leader – it is essential to determine which variables can have an impact on these factors to better understand and model respective processes.

As CH leadership is a new research topic, we did not find any studies examining the acceptance of computers as leaders. However, HCI researchers developed the Technology Acceptance Model (TAM; Davis, 1986; and its revisions, e.g., TAM2 by Venkatesh & Davis, 2000), a model predicting individual adoption and use of technology, that has been successfully applied to a broad range of different technologies (e.g., office automation tools like spreadsheets and text-editors, software development tools like programming or debugging tools, or business application tools like production control tools; Legris, Ingham, & Collerette, 2003).

However, as we stated above, the profound change in hierarchy that CH leadership implies (i.e., humans as subordinates and not as users or consumers of technology; e.g., Lee, 2018) requires a re-evaluation of existing models of general HCI. We argue that the TAM and its revisions might be well suited to explain acceptance of 'computers as tools' but is not sufficient to explain the acceptance of 'computers as leaders'. Therefore, we suggest to synergistically combine the general HCI-model of technology acceptance (Davis, 1986; Venkatesh & Bala, 2008; Venkatesh & Davis, 2000) with the HHI-model of leader legitimacy and acceptance (see section 4; Tost, 2011) to result in a modified version of the TAM, the L-TAM (LeadershipTAM, see Fig. 2). With the L-TAM we seek to explain the processes leading to the acceptance of computer leaders by human subordinates in the context of CH leadership by providing a generic model that can be used to evaluate computer leaders that automate one, more or all of the identified leadership functions (cf. Table 2).

4.2. The LeadershipTAM

The core proposition of the TAM and its revisions (Venkatesh & Bala, 2008; Venkatesh & Davis, 2000) is that actual use behavior is determined by the respective behavioral intention, which in turn is mainly determined by two beliefs: *perceived usefulness* and *perceived ease of use*. While perceived usefulness is considered as a belief describing the extent to which a person expects that the use of a system will enhance his or her job performance (Davis, Bagozzi, & Warshaw, 1989), perceived ease of use (Davis et al., 1989) is defined as a belief about the effort and difficulties linked with the use of a system. Moreover, Venkatesh and Bala (2008) postulate that the two core beliefs of the TAM, perceived usefulness and perceived ease of use, are determined by four different types of variables: social influences, system characteristics, facilitating conditions, and individual differences.

Meta-analytic evidence corroborates the core propositions of the TAM regarding the predictors of actual use of different technological applications (King & He, 2006). Thus, we assume that also a computer leader needs to be perceived as useful and the interaction with the system must be effortless and natural to be followed by human subordinates. In the following, we will review existing evidence on the proposed relationships between the components of the original TAM and its revisions and will discuss their meaning in the context of CH leadership. Doing so, we will refrain from elaborating on the category of individual differences of users as determinants of perceived ease of use (cf. Venkatesh & Bala, 2008) due to our focus on system characteristics and their – individual and social – perception. Instead, we will differentiate system characteristics more fine-grained into output-related, experience-related and leadership-related characteristics.

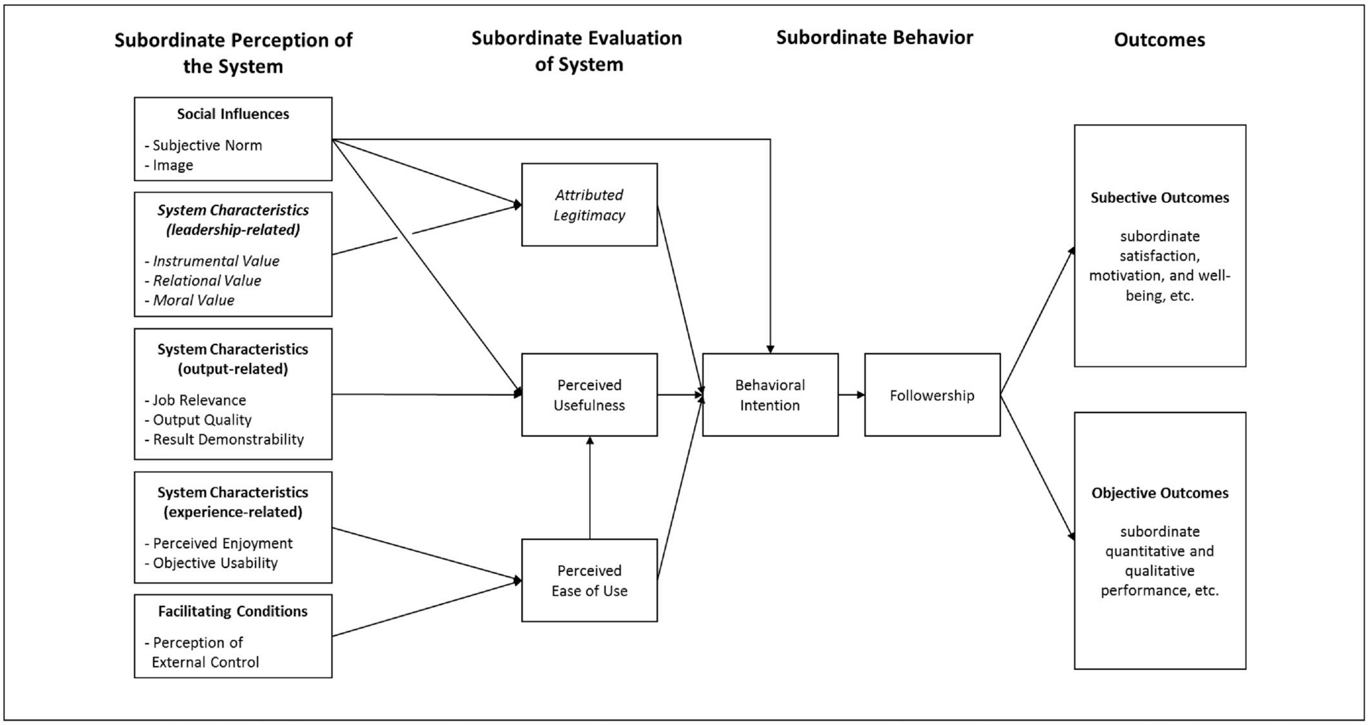
4.2.1. Social influences

TAM's core belief of perceived usefulness is associated with the degree to which a person thinks that his or her social environment might appreciate or reject the use of the system (Glass & Li, 2010; Karaali, Gumussoy, & Calisir, 2011; Venkatesh & Davis, 2000). Research based on the original TAM and its extended versions has shown that such *subjective norms* are linked with perceived usefulness (Taylor & Todd, 1995; Venkatesh & Davis, 2000; Yoon, 2018), but relate also to behavioral intentions to use the system, especially if the use of the system is mandatory and not of one's own free will (Hartwick & Barki, 1994; Venkatesh & Davis, 2000). In the context of CH Leadership, this might imply that the perceived usefulness of the computer leader depends on the subordinate's social context and the opinions and attitudes of important individuals of reference (or also the 'zeitgeist'). In addition, subjective norms might play an important role for the attributed legitimacy of a computer leader as well as for behavioral intentions of subordinates.

A second social factor predicting perceived usefulness is referred to as *image*, the perceived effect the use of a system might have on one's social status (Moore & Benbasat, 1991). Research suggests that the use of innovative information technology is linked with a higher social status within a group and hence positively relates to perceived usefulness (Vaterlaus, Patten, Roche, & Young, 2015; Venkatesh & Bala, 2008). Since previous studies have shown that image is associated with subjective norms (Venkatesh & Davis, 2000; Yoon, 2018), it can be assumed that the influence of this factor in the L-TAM is depending on the general attitudes significant others have towards automated leadership. If they generally consider working in an organization that automates its leadership functions to be a privilege, it can be expected that image positively influences perceived usefulness of the system. Interestingly, the effects of social factors (i.e. image and social norms) seem to attenuate over time as users gain more experience with a system (Venkatesh & Bala, 2008). Therefore, it could be speculated that the influence of social factors might be of lesser importance for CH leadership in the long run.

4.2.2. Output-related system characteristics

In addition, perceived usefulness is influenced by three cognitive instrumental processes according to the TAM2 (Venkatesh & Davis, 2000). *Job relevance* represents the degree to which an individual believes that the system is applicable to his or her job. *Output quality* describes the perceived task performance of the system and *result demonstrability* depicts the belief that the outcomes of the use of the system are tangible, observable and communicable. All three concepts



Note. Individual subordinate characteristics as proposed in the TAM3 (Venkatesh & Bala, 2008) like computer self-efficacy, anxiety or playfulness have been omitted in this figure due to a focus on system characteristics and their perception.

Fig. 2. Technology Acceptance Model adapted to predict human subordinates' followership of computer leaders.

have previously been shown to be linked with perceived usefulness (Venkatesh & Bala, 2008; Venkatesh & Davis, 2000) and hence might as well play a role in the L-TAM. For computer leadership, it might therefore be important that a subordinate believes that automated leadership is applicable to his or her job, that the computer leader performs well and that the work outcomes can be measured and reported in an understandable and appealing way.

4.2.3. Experience-related system characteristics

Venkatesh (2000) proposed *objective usability* and *perceived enjoyment* as system characteristics determining perceived ease of use. Building on that, we regard it important for the ease of use of CH leadership that the usability of the system is high. In addition, the interaction with the computer leader should be joyful and pleasant. Research in the domain of HCI has shown that aesthetically pleasing designs (Norman, 2002), gamification (Deterding, Sicart, Nacke, O'Hara, & Dixon, 2011), or captivating content (Aranyi & van Schaik, 2015) can lead to positive experiences. For computer leaders, other interaction characteristics might be more important. Aspects such as an agreeable voice, humor and empathy have been shown to positively influence the experience of the interaction with a robot (Chang, Lu, & Yang, 2018; Niculescu, van Dijk, Nijholt, Li, & See, 2013) and also might lead to perceived enjoyment of interactions with a computer leader.

4.2.4. Facilitating conditions

As additional determinants of a systems' ease of use, Venkatesh and Bala (2008) propose *perceptions of external control.* These represent control beliefs about organizational resources and support being available to facilitate the use of the system (Karaali et al., 2011; Venkatesh, 2000). In the context of CH leadership, this implies that organizational measures such as help desks or continuous training that might positively influence perceived ease of use of the system.

4.2.5. Leadership-related system characteristics

While we regard the described influencing factors of the original TAM and its revisions as important for acceptance of the technology per se, we propose that the above described skepticisms humans might have about subordinating to a computer leader (see section 4.1) plays a key role in the L-TAM and might not yet be accounted for in the original versions. Thus, we propose to add a path (represented in italic in Fig. 2) of attributed legitimacy, which is influenced by three evaluations of a computer leader: (1) instrumental value: the perception of competence, efficiency, and effectiveness, (2) relational value: the perception of favorable consequences regarding social status, social identity, and self-worth, and (3) moral value: the perception of moral and ethical integrity of the computer leader (see section 4; Tost, 2011). Some of these additional factors of the L-TAM influencing attributed legitimacy show certain overlaps with components of the TAM in its original versions. For example, perceived relational value of a CH leadership system might be linked with social influence factors of the original TAM (i.e. subjective norm and image). Moreover, job relevance, output quality and result demonstrability as predictors of perceived usefulness in the original TAM version might share some variance with the perceived instrumental value of the CH leader predicting attributed legitimacy.

We propose that this new path of attributed legitimacy in combination with the paths of the original TAM and its revisions, perceived usefulness and perceived ease of use, can depict users' intentions to follow the computer leader (i.e. leader acceptance) and actual followership behavior. Naturally, this new path of attributed legitimacy and its determinants require thorough empirical testing. This includes not only the development of instruments to assess the corresponding concepts, but might also imply to take into consideration additional future developments of the TAM and its multiple derivatives (e.g., van der Heijden, 2004; Venkatesh, Morris, Davis, & Davis, 2003).

4.2.6. L-TAM outcomes

As outcome measures of the L-TAM, which can also be considered criteria for a successful implementation of a CH leadership system, we propose objective (e.g., performance, errors) and subjective (e.g., trust, satisfaction with the job and with the leader, and well-being) indicators as described in section 3.3.

Although we are aware of the problem that knowledge from the domains of HHI and classical HCI might not always be directly transferable to questions of CH leadership (Jamieson & Skraaning, under review), we argue that the L-TAM can serve as a systematic model to derive and empirically explore factors that influence human subordinates' acceptance and followership of computer leaders and thus might guide future developments of automated management systems.

5. Implications and future perspectives of CH leadership

With our article we aim at proposing a new perspective on hierarchical relationships and roles in HCI and at starting a theoretical and empirical discourse on the paradigm of 'computers as leaders'. We see ample aspects that should be examined and discussed in the future.

5.1. Future research: theoretically and empirically exploring CH leadership

As Lee (2018) emphasizes, computers assuming leadership roles puts interacting humans into a very different power structure than when they are 'users' or 'consumers' interacting with computers. This profound change in hierarchical relations implies, that established models in HCI need to be reviewed regarding their applicability in the paradigm 'computers as leaders' and where necessary need to be extended or adapted, as we demonstrated with the Technology Acceptance Model (TAM; Davis, 1986; see section 4.2). We believe that rethinking and enlarging the paradigms used to model human-computer interaction can unleash great creative powers, just as we witnessed in the 1990s with the emergence of the paradigm 'computers as partners' that inspired researchers to conceive HCI in a new way (e.g., Jamieson & Skraaning, 2018). Back then, HCI research benefitted from research in HHI with psychological constructs like team processes (Nass, Fogg, & Moon, 1996), trust (Muir, 1994), or cooperation (Hoc, 2000) being successfully transferred to and adapted for HCI. We hope that our proposed paradigm, 'computers as leaders', similarly inspires researchers in both disciplines, i.e., in HCI and automation and in HH leadership. Established models from HH leadership research might serve as sources of inspiration, discussion and controversial questioning for a start in the exploration of the field of CH leadership. While vice versa, insights from HCI might help HH leadership researchers to better understand interactions happening at modern workplaces that no longer only consist of human agents but also include computer agents.

Alongside theoretical conceptualization, empirical research is needed to test the validity of concepts and models developed for CH leadership situations. An important research question concerns function allocation between human and computer leaders, that is the question of which leadership functions should be automated, and which should be performed by human leaders. Lee (2018) took a first step in this direction and explored with hypothetical scenarios how humans would respond to a human vs. an algorithmic leader that decides about work assignments, work scheduling, hiring, or work evaluations. Respondents gave information regarding perceived fairness of the decision, trust in the reliability and accuracy of the decision, and emotions resulting from the decision. Similarly, Ötting and Maier (2018) tested with hypothetical scenarios how humans would respond to a human vs. a robotic vs. an algorithmic decision-maker that allocates tasks in a work team (study 1) and selects employees to participate in vocational training (study 2). They manipulated the fairness of the decision and asked participants to indicate their anticipated job satisfaction, organizational commitment, willingness to cooperate as well as extra-productive and counterproductive work performance. For future research, we recommend to explore the question of allocating leadership functions between human and computer leaders more systematically, based on established taxonomies of leadership functions (see section 3.4., e.g., Fleishman et al., 1991) and against a predetermined set of evaluative criteria that takes into account both, subjective and objective measures as consequences of leadership behavior (see section 3.3).

A second important research question concerns human subordinates' acceptance of and followership to computer leaders. Geiskkovitch et al. (2016) made a first step in this direction and transferred the concept of authority from HH leadership research to CH leadership research. They empirically compared human subordinates' followership to directives by an autonomous robot leader vs. a non-autonomous remote-controlled robot leader vs. a human leader. Moreover, they tested different factors that might influence robot authority, e.g., the level of perceived robot autonomy and level of perceived human-vs. machine-resemblance. Similarly, Derrick and Elson (2018) investigated the influence of computer leader embodiment (i.e., text-based, hologram-based, and screen-displayed embodied agents) on the performance and satisfaction of human subordinates. We propose that taking into account new models (e.g. the L-TAM presented in this article) helps to systematically derive factors influencing subordinates' acceptance and followership to computer leaders. Taken together, we argue that more research in this area is needed that conceptually and empirically broadens our knowledge in systematic ways about computers performing leadership functions and humans' responses to it.

5.2. Future perspectives: autonomous CH leadership

Throughout the article we limited our reflections to scenarios in which computers act like middle managers, i.e., where computers supervise and decide in specific allocated tasks according to standards and goals set and programmed by (higher-level) human leaders. Such arrangements can already be found in current workplaces. However, if we think a few years ahead, given an ongoing high pace of technological advancement, it might be possible that there will be situations in which computers lead humans completely autonomously (Ferràs-Hernández, 2018). Avolio et al. (2014) regard the possibility of computers or robots fully controlling leadership processes as "unlikely, yet interesting to consider" (p. 117). Similarly, Sheridan (2016, p. 531) sees the aforementioned axiom of human command over computers unshaken: "all robots for the foreseeable future will be controlled by humans, either as teleoperators steered by continuous manual movement or as telerobots intermittently monitored and reprogrammed by human supervisors". However, Inagaki and Sheridan (2012, p. 30) also consider possible exceptions to the axiom: "Should such an intelligent machine sit back when it detects a human's apparently inappropriate control action, by assuming that the human must have some good reason for doing so? Allowing a machine to take a corrective control action when it believes that the human is late in taking a necessary measure or behaving inappropriately implies that the authority is traded from the human to the machine temporarily. […] machine-initiated trading of authority may be indispensable even in the framework of human-centered automation when safety of human-machine systems is a major factor."

Considering that even nowadays entire branches of industry depend on algorithmic decision-making (e.g., ride sharing providers, dating platforms, hiring platforms, etc.), we argue that autonomous computer leaders (i.e., computers making decisions and commanding human subordinates in organizations without the need of approval by higher-level human leaders) might present a realistic scenario for the near future. While such a scenario might come with many positive outcomes for organizations and humans at work, it implies also potential dangers and uncertainties for individuals, society and humanity. In the following, we will discuss ethical implications arising from computer leaders adopting an increasing level of autonomy and decision power at future workplaces.

5.3. Ethical implications of automated leadership

As Arkin (2016, p. 1779) notes, "We are creating autonomous technology faster than we are able to 1) understand its implications; 2) interpret it within moral frameworks; and 3) create policy and legislation to govern its development and deployment." The urgent need to understand the implications and adapt respective policies and legislations to the technological progress of automated systems has also been discussed in other domains of HCI research such as automated driving (Birnbacher & Birnbacher, 2017; Goodall, 2014), drones and robots in warfare (Arkin, 2009), social robots (Zhao, 2006), robots in nursing care (Pols, 2017; van Wynsberghe, 2016), or android sex workers (Yeoman & Mars, 2012).

We must not forget that in the case of automated leadership, computers do not manipulate inanimate objects, like data, materials or products, but lead and manage human beings. As leaders, they are not 'ordinary' organization members, but hold prominent positions in organizations whose decisions and behaviors directly and indirectly affect the organization and the lives of their subordinates. Not only do they make important decisions for their employees (e.g., hiring and firing, promotions and pay, work tasks and shifts, etc.) and the organization (e.g., where and when to invest or save resources), they also influence the culture and climate in organizations. Due to this tremendous impact that leaders have on the lives of their subordinates and their organizations, ethics are an intensely researched and discussed topic in HH leadership research (see the meta-analyses by Bedi, Alpaslan, & Green, 2016; Ng & Feldman, 2015).

In line with our synergistic approach, we call for a specialized discussion of ethical issues of leadership automation that considers ethical standards both from the field of HCI and automation and from the field of HH leadership and management. The IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems (2019) proposes five general ethical principles applicable to all types of autonomous and intelligent systems: 1) ensure that systems do not infringe on human rights, 2) prioritize human well-being in system design and use, 3) ensure that system designers, manufacturers, owners, and operators are responsible and accountable, 4) ensure that systems operate in a transparent manner, 5) be aware and minimize the risks of system misuse. Focusing on concrete leader behavior, Eisenbeiss (2012) identifies four central orientations of ethical leadership: 1) humane orientation (referring to treating others with dignity and respect and to see them as ends, not as means), 2) justice orientation (referring to making fair and consistent decisions), 3) responsibility and sustainability orientation (referring to leaders' long-term views on success and their concern for the welfare of society and the environment), and 4) moderation orientation (referring to leaders' temperance and humility and balanced leader behavior). We advocate that a synergistic combination of such system-focused and leader behavior-focused ethical standards provides a good starting point to delineate ethical standards for computers in leader positions.

Given that the implementation of autonomous and intelligent systems is inevitable (e.g., Hancock, 2014), research effort in HCI might be better spent investigating how we can design them to improve human well-being and advance humanity instead of campaigning against their development. In the context of computers as leaders, the question should therefore not be whether to automate or not, but rather how automation can be designed in a way that generates work environments conducive to human satisfaction and well-being. To do so, we need to know about the strengths, but we must also be aware of risks and consequences of the deployment of automated management systems. Research in HCI needs to address and document such pitfalls and dangers empirically in order to guide the inevitable and ever-advancing technological development in this field.

6. Conclusion

As Chamorro-Premuzic and Ahmetoglu (2016) state, a world in which computers are leading humans may sound far-fetched and dystopic, but it is actually more probable than most people might think. In combination with an accelerating technological development, the ongoing deployment of automated systems in our workplaces has led to work environments in which more and more leadership functions are already performed by computers (Harms & Han, 2019). The overarching goal of our article was to draw attention to this issue and assert that the theoretical development in HCI is in danger of lagging behind already implemented applications. To adequately account for this 'evolution' of technology at work, we proposed to extend the paradigm with which we conceptualize computers in HCI from 'tool' over 'partner/teammate' to 'leader'. In line with Geiskkovitch et al. (2016) and Lee (2018), we argue that it is crucial to scientifically examine the issue of computers in leadership positions and to develop an understanding of the interaction dynamics in CH leadership situations as practical applications are about to be, or are already, implemented. Moreover, the scientific discussion on 'computers as leaders' should objectively examine not only the risks, but also the opportunities associated with this next step in automation development (see also Geiskkovitch et al., 2016; Young & Cormier, 2014) and not leave these questions to the commercial providers of such products and applications that are potentially biased in their evaluation.

With our contribution, we intend to open up a new perspective on the hierarchical relationships and roles in HCI. We want to start a theoretical and empirical discourse on the paradigm 'computers as leaders', because the world has changed since 1967, when Peter Drucker stated that computers are morons and make no decisions. Computers are becoming intelligent entities and are already making decisions that seriously influence human work and life. They evolved from 'tools' to 'partners' to 'leaders' in their interactions with humans and conceptual coverage is in danger of falling short of this development. For us, it is the responsibility of researchers to explore both the potential and the pitfalls of computers in leadership positions and also, to provide human decision-makers in society, business and governments with the knowledge to be able to make careful and informed decisions about humans' interactions with computer agents in all the different areas concerned.

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