Shielding Focus Against Distractions: Designing Focus Assistants for Knowledge Workers

Short Paper

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Abstract

Technological developments in information technology enabled the ubiquitous emergence of instant messages and push notifications in private and work lives. Moreover, open plan office designs and organizational shifts such as agile methodologies further tighten interactions among employees. These new opportunities, however, also pose a double-edge sword in that large amounts of unwanted information may repeatedly draw attention from the primary task, thus distracting and preventing knowledge workers from working effectively. In this paper, we present a design science research project on how to design a focus assistant that shields its users against digital and physical distractions to sustain their focus. Drawing on literature on attention, focus and distraction, we developed seven design principles and derived first potential features for a prototype. By developing the basis to build an artifact, we intend to contribute to the constituent IS community on assisting workers in technology-enabled work arrangements.

Keywords: distraction, interruption, focus, attention, concentration, assistant, inhibition, blocking, inattentional blindness, load theory

Introduction

In the age of ever-increasing amount of information available at our fingertips, services built on information systems (IS) permanently fight for our attention. Incoming e-mails, instant messages and push notifications can help users to stay up-to-date and motivated, yet emerging at the wrong time these unwanted information deliveries can pose distractions to a user's focus. This is especially a problem for knowledge workers, who typically need to work with IS devices to solve complex tasks (Reinhardt et al. 2011). Moreover, distractions caused by IS add to the distractions in the worker's physical environment, which can range from regular office noise to a colleague actively interrupting the worker's focus. Once a distraction leads to an interruption of the workflow, it takes the knowledge worker on average 25 minutes to refocus on the original task (Mark et al. 2005). In a recent survey by Udemy Research (2018), 54% of the respondents felt that distractions led them to decrease their performance, and 62% claimed to lose at least an hour per workday just by checking their smartphones.

In this research project, we intend to investigate how to design an IS-based focus assistant to reduce the effect of distractions on knowledge workers who need to focus on complex tasks using their IS devices. The proposed focus assistant is an artifact running on the knowledge worker's IS devices that employs various countermeasures to block, mask and attenuate distractions, minimize perception of distractions, as well as avoid shifts in knowledge worker's attention. We particularly include physical as well as IS-related distractions into our scope to support knowledge workers. Research has hitherto neglected this approach: Existing IS-based solutions in research are limited to individual distraction countermeasures (e.g. Sykes (2011)) or to one-sided ways of managing distractions, such as determining the best time for a worker to be interrupted (Hincapié-Ramos et al. 2011). Similarly, software companies have acknowledged the issue of emerging distractions and addressed it by starting to implement solutions like "do not disturb"-modes. Yet, these approaches suffer limitations in that they (1) commonly lack adaptability as well as proactivity, (2) are limited to blocking notifications, and (3) can pose a distraction in themselves. Given the current limitations of distraction minimizing solutions, further research is necessary to guide the design to effectively shield knowledge workers from distractions. Thus, we ask the following question:

RQ: How to design focus assistants to shield knowledge workers against digital and physical distractions to sustain their focus on tasks?

To answer this question, we follow the design science approach by Peffers et al. (2007) to develop a design consisting of multiple subtasks that contribute towards our overall goals of increased focus. The design's main components are (1) the autonomous detection when a knowledge worker is engaging in a complex task warranting activation of the system, so that this critical moment is not interrupted by a need for manual action; (2) the proactive application of multiple distraction countermeasures that cannot only block distraction but also mitigate the impact of unblockable distractions originating from both the digital devices and the physical environment; and (3) the continuous tailoring of the applied distraction countermeasures to the individual knowledge worker by collecting noncompulsory feedback on the focus assistant's effectiveness. Our proposed design, consisting of seven design principles, is the main result of this research-in-progress paper. In a later stage, we will implement an instantiation and evaluate its performance regarding its effectiveness and user acceptance.

Our major contribution for researchers and practitioners consists of a design for an artifact that would provide knowledge workers with a tool to increase their productivity when working on complex tasks, thus increasing knowledge worker's efficiency and freeing-up time for other activities. In contrast to existing approaches, our comprehensive approach comprises countermeasures against distractions from both the digital and the physical environment, thus extending previous endeavors in practice and research that focused mainly on digital distractions. Moreover, our design considers the minimization of interactions between the knowledge worker and the assistant during the high focus phase, while at same time ascertaining flexibility and adaptability in the focus assistant.

Related Work

The theoretical background presented in this section addresses concepts and key relations of focus, attention and distraction as well as highlights previous work on IT artifacts combatting the effects of distractions. In the section on design principles (preliminary results, phase 3), we build on concepts of the attention economy such as perceptual load, cognitive load and capacity theory.

Focus, Attention and Distraction of Knowledge Workers

The main feature of knowledge work is that its basic task is creative thinking (Reinhardt et al. 2011): Typical activities of knowledge workers are – among others – analysis, authoring, information search, learning and feedback. These activities require knowledge workers to regularly perform complex tasks that cause high mental workload. When a knowledge worker wants to *focus* on a complex task, he or she needs to employ *attention and ignore distractions* (Moran 2012). Attention is a multidimensional construct that refers to at least three distinct cognitive processes (Moran 2012): concentration, selectivity of perception and ability to coordinate two or more actions at the same time. Distractions on the other hand are "psychological reactions triggered by external stimuli or secondary activities that interrupt focused concentration on a primary task" (Jett 2003, p. 500). Distractions are not self-initiated and compete for attention with simultaneous performance of a primary task, but are irrelevant to the successful completion of the primary task (Jett 2003). When using the term *interruptions*, we refer to a special case of distractions which occurs if the external stimuli cause the knowledge worker to shift his or her attention away from the primary task and cognitive effort would be required to return to it (Damrad-Frye and Laird 1989; Galluch et al. 2015) (conflicting definitions for this term exist, e.g. Jett (2003)).

Distractions can be divided into *internal* distractions, which result from one's own thought processes, and *external* distractions, which result from stimuli from one's environment (Mark et al. 2005; Miyata and Norman 1986). Speier et al. (2003) distinguish external distractions detected by *sensory channels different* from those used for the primary task from external distractions detected by the *same sensory channels*. Distractions perceived by different sensory channels can be ignored or processed concurrently to the primary task (Cohen 1980; Speier et al. 2003), in contrast to the latter. Furthermore, external distractions can originate from one's physical or digital environment. Examples of physical distractions in a knowledge worker context include primarily auditory (e.g., background speech and sounds) and visual distractions (e.g., passing people), whereas digital or IS-related distractions encompass mainly email or calendar notifications, system update or in-page advertising (Roper and Juneja 2008; Sykes 2011; Wojdynski and Bang 2016).

Distractions can directly impact a knowledge worker's productivity. Adler and Benbunan-Fich (2015) point out that productivity reaches optimal levels if mental workload – caused by task complexity – is neither too low (entailing boredom), nor too high (entailing overload). Furthermore, the authors summarize that distractions and resulting multitasking lead to increase of mental workload, which benefits phases of trivial tasks, but impairs productivity in phases of complex tasks. Hence, distractions are particularly detrimental when knowledge workers engage in complex tasks.

Literature Review of IS-related Distraction Countermeasures

To understand how research investigates the role of IS in combating distractions for knowledge workers, we conducted a systematic literature review (Vom Brocke et al. 2015) using the databases AISeL, ACM Digital Library, IEEE Xplore Digital Library, Scopus and EBSCOhost. We focused our search on contributions that suggested or developed technology-based countermeasures against distractions, excluding literature only explaining or measuring distractions. Our search terms included synonyms of prevention, distraction, workplace, technology and interaction. After initially reviewing 125 papers and conducting a forward/ backward search, we identified 6 relevant publications that discuss IS-based distraction countermeasures.

Sykes (2011) proposes to make use of existing technological options, such as disabling notifications in email and instant messaging applications or applying (noise-cancelling) earphones. Mark et al. (2017) go one step further and develop a temptation blocker, denying access to websites and applications notorious for distractions. However, rigid deactivation or permanent blocking of distractions may not be desirable for collaborative efforts requiring communication. This led researchers to the idea of adaptive countermeasures that postpone delivery of communication-related notifications (Fogarty et al. 2005; Hincapié-Ramos et al. 2011; Prajapati et al. 2016; Schaule et al. 2018). The core underlying principle is to develop detection mechanisms capable of determining whether a user can currently accept an interruption without disrupting a task that requires continues attention. Detection of adequacy to interrupt has been based on physiological sensors (Schaule et al. 2018) and computer activity information serving as proxies for mental workload (Fogarty et al. 2005). Information about how well a person can be interrupted in a given moment is used for a broad area of research developing availability-sharing systems that facilitate potential interrupters in their decision on whether to reach out to a colleague or not (see Hincapié-Ramos et al. (2011) for a review). Prajapati et al. (2016) go beyond detection of availability by developing an interruption-information management software that intervenes in the handling of chat messages in an instant messaging application. Specifically, the tool analyzes several factors relating to the context of the message, the current behavior of the sender as well as the receiver and the sender-receiver-relationship to determine when a message is sent and when it is displayed, effectively reducing disruption of tasks.

The proposed IS-based distraction countermeasures offer useful approaches, yet multiple issues remain unaddressed. First, to the best of our knowledge no solution exists that pursues a holistic approach towards distractions. This implies developing countermeasures that address multiple distraction sources beyond communication notifications (e.g., interface elements, auditory distractions), and that extend to all IS devices used by a knowledge worker. Second, adaptability functions have been developed using pretrained models, rather than adaptation to individual user needs by continuous learning from user behavior and feedback. Third, countermeasures fail to address the psychological processes that help knowledge workers ignore distractions. We intend to address these gaps by developing a design for an artifact for holistic distraction countermeasures.

Methodology

This research project uses a design science approach in the style of Hevner et al. (2004), which allows us to derive our design by applying rigor using the scientific literature and incorporating practical considerations, ensuring relevance. We structured the project along the phase model for design science by Peffers et al. (2007):

In phase (1), we motivated and specified the problem from theoretical and practical perspectives. After investigating literature on focus, attention and distractions, we used our theoretical findings to conduct an innovation workshop with two industry experts and two IT consultants to delineate the problem scope and possible solution approaches. For phase (2), we defined qualitative and quantitative solution objectives, using the knowledge gathered in the first phase. Currently, our research project is in phase (3), design and development: For this phase, we analyzed the identified literature as well as the results from the innovation workshop, to ensure a solid theoretical fundament, innovativeness and practicability of our proposed focus assistant. We developed our design in three stages: First, we identified 27 *design requirements*, which comprise “generic requirements that any artifact instantiated from this design should meet” (Meth et al. 2015, p. 807). Those were then generalized into 7 *design principles* which describe the “artifact’s generic capabilities corresponding to the proposed design through which it addresses its requirements” (Meth et al. 2015, p. 807). Finally, we derived 35 *design features*, which reflect one specific way to implement the design principles in an instantiation of the artifact (Meth et al. 2015). At each stage, the four authors independently developed their results, which were then consolidated mutually.

Preliminary Results

Problem Scope Definition (Phase 1)

Knowledge workers face an increasing amount of external distractions in their workplace, mainly driven by open plan office designs and intrusive IS (e.g., instant messaging and push notifications) (Sykes 2011). Distractions have clearly been linked to experiencing more stress, higher frustration, time pressure and effort (Mark et al. 2008). Our proposed solution aims at external distractions, both physical and IS-related. In principal, knowledge workers have various options to combat distractions: Examples encompass disabling notifications, silencing phones and using earphones to mask conversations (Sykes 2011). However, the knowledge worker (1) is restricted to features implemented by manufacturers (e.g., option to disable notifications), (2) needs to know of the existence of these countermeasures, (3) needs to be aware his or her focus is being diverted due to a distraction irrelevant to the current task and (4) must invest resources in activating these countermeasures. Hence, we argue that to effectively and efficiently avert the perils of ubiquitously emerging distractions, the knowledge worker requires an IS artifact – a focus assistant (FA) – that assists a knowledge worker in shielding his or her focus against distractions.

Solution Objective Definition (Phase 2)

The central objective of our solution is to help knowledge workers maintain focus on their primary task by using our artifact. This will be measured through the objective proxy variables *length of the high focus phase* and *number of task switches during the high focus phase*. They are supplemented by subjective variables, namely *subjective effectiveness of countermeasures* and *subjective impression of own productivity*. The subjective variables also contribute to the user’s level of acceptance of the artifact.

We divided the FA’s basic functionality into five subtasks as depicted in figure 1. The successful realizations of these subtasks serve as intermediate objectives towards the fulfillment of the four aforementioned overall objectives. (1) The FA’s first subtask concerns the detection that the knowledge worker engages in a complex task by observing her/his behavior (e.g., mouse/keyboard activity) (Roda and Thomas 2006), so that there is no interruption by turning on the FA manually. This marks the beginning of the *high focus phase*. (2) During this phase, the FA activates several distraction countermeasures to safeguard the knowledge worker's attention, e.g., blocking notifications (detailed in design principles). The applied countermeasures may be adjusted throughout the high focus phase to match changing needs of the knowledge worker. (3) The FA detects the end of the high focus phase, when the user ceases working on the complex task. It then deactivates all countermeasures and (4) provides a comprehensive report on the relevant events the user missed. Finally, (5) the FA collects voluntary user feedback on its effectiveness in the last high focus phase on a sample basis. The feedback will be applied by the FA to improve its detection and applied countermeasures for the next high focus phase.

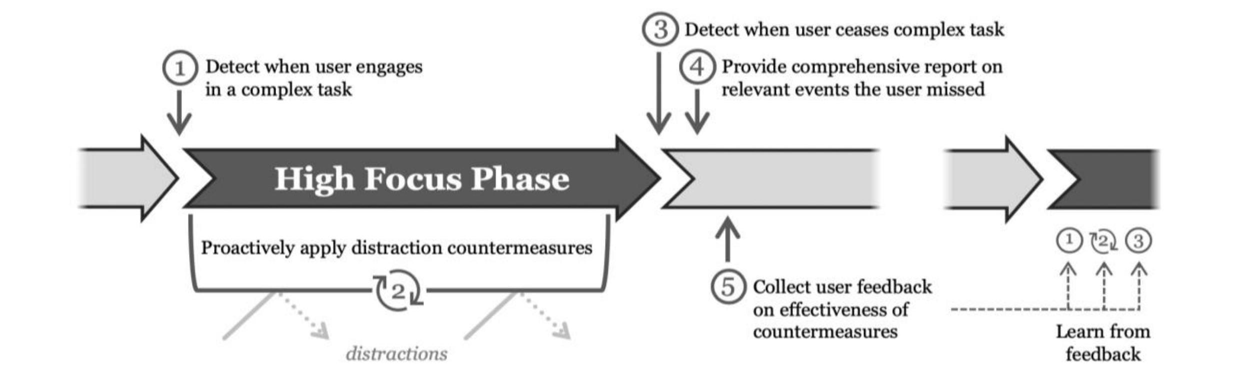

Figure 1. Functionality of the Proposed Focus Assistant

Design Principles (Phase 3)

Our proposed design consists of seven design principles (DP). For each of them, we present a subset of the design features (denoted as [DF]), which we will implement in the first instantiation of the artifact. Future design science iterations based on evaluation of the instantiations will lead to the refinement of our design.

The first three design principles resemble the core of our design. They represent countermeasures based on the causal chain of distractions (figure 2), which we derived as an extension of the computational model of selective attention (Neokleous et al. 2016): *Distractions* that are prominent enough to be noticed by the knowledge worker are considered as *emerging distractions*, which – depending on the knowledge worker's available perceptual resources – lead to *perception of distractions*, which in case of unsuccessful inhibition finally cause an *attentional shift towards the distraction*.

DP1: Attenuate, block and/or mask distractions.

A simple as well as effective type of countermeasure eliminates or reduces the impact of distractions before they emerge. We distinguish between physical and IS-related distractions: Ambient physical stimuli that can easily be addressed by current technology refer to auditory distractions, which upon detection may be attenuated through noise-cancelling earphones [DF] or masked by playing music or sounds [DF] (Sykes 2011). Regarding IS-related distractions, exemplary features may encompass (1) hiding irrelevant items (e.g., blurring background windows, minimizing interface menus, suppressing suggestions to irrelevant apps) [DF], (2) disabling notification popups and badges on desktop and mobile devices (e.g., email, instant messaging, updates, system information) [DF] and (3) indicating a 'busy' status to colleagues (e.g., within instant messenger) [DF].

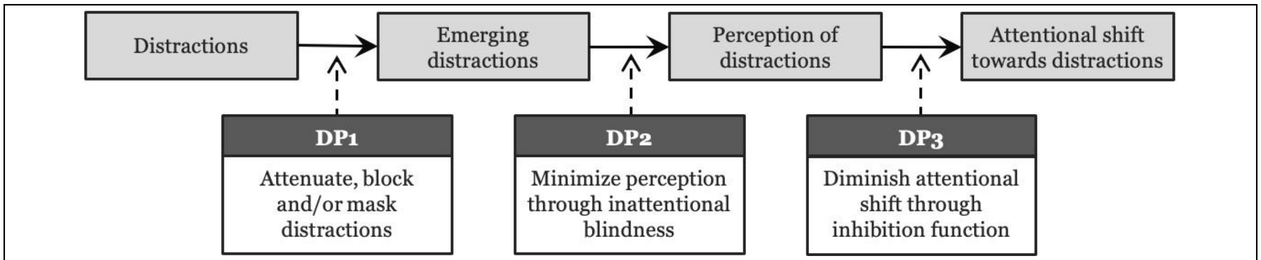

Figure 2. The Focus Assistant's Countermeasures Along the Causal Chain of Distractions

Underlying theory: The cognitive process of controlling focus is determined by a balance between (1) a *goal-oriented* process influenced by knowledge, expectation and current goals and (2) a *stimulus-driven* process responding to salient and unattended stimuli (Corbetta and Shulman 2002). When the influence of (2) outweighs (1), attention is redirected and concentration is lost, also known as the spotlight metaphor (Moran 2012). Hence, it is critical to limit the salience of distracting stimuli, e.g., by reducing their color, dynamism or auditory features (Tams 2011). If possible, stimuli should be blocked or masked entirely.

DP2: Minimize the user's perception of emerging distractions through *inattentional blindness*.

This set of countermeasures aims at distractions that are not amenable through DP1. Stimuli can still be prevented from being perceived by the knowledge worker due to a phenomenon known as *inattentional blindness* (Lavie 2010), which can be purposefully induced by e.g.: (1) Limiting legibility of text (e.g., setting maximum font sizes, fading text slightly) [DF] (Halin et al. 2014), (2) decreasing zoom in graphical interfaces (e.g., during image search, in drawing programs) [DF] and (3) conveying information on multiple sensory channels (e.g., displaying subtitles in videos) [DF].

Underlying theory: The theory of attention and cognitive control proposed by Lavie (2010) emphasizes high *perceptual load* of the task at hand as a shield against distraction: perceptual resources are occupied to an extent that only a few or no other stimuli can be perceived (e.g., while playing a video game). As pointed out by Lavie (2010), it is critical to understand that inattentional blindness is caused by perceptual load only, not by general task difficulty (characterized by multitasking or high working memory load). Manipulation of perceptual load has been suggested for recognition tasks by increasing the quantity of different items to recognize or by increasing number and complexity of perceptual operations required by the task (Lavie et al. 2009).

DP3: Diminish attentional shift towards distractions through the user's *inhibition function*.

The last line of defense is represented by the *inhibition function*, which applies attentional control such that the knowledge worker can resist interference from task-irrelevant stimuli (Miyake et al. 2000). Avoiding task switching and supporting working memory can aid to preserve inhibition capabilities, implemented, e.g., by: providing a regular report of extent of task switching during last high focus phases to foster the user's discipline [DF] and by offering a digital scratchpad to temporarily store information, relieving the working memory [DF]. Mood-enhancing measures such as changing screen color and light temperature [DF] to induce more relaxation can further support the inhibition function (Gorn et al. 2004). Mental restoring measures after high focus phases such as playing user-customized music [DF] or displaying images of nature can revitalize the inhibition function after fatigue (Schwarz and Kaplan 2000).

Underlying theory: The inhibition function keeps the stimulus-driven attention system in check and increases in effectivity when a goal is pursued more adamantly, e.g., by setting intentions (Veling and Van Knippenberg 2006). The inhibition function shares the same cognitive control resources as the shifting function – responsible for task switching – and the updating function – responsible for working memory – which jointly determine the level of cognitive load (Eysenck et al. 2007; Lavie 2010). Furthermore, attentional control theory emphasizes anxiety as detrimental to the inhibition function (Eysenck et al. 2007). Lastly, mental fatigue due to enduring suppression of irrelevant stimuli weakens the inhibition function as well (Schwarz and Kaplan 2000) – in line with *capacity theory's* proposition of reduced attentional capacity in conditions of low arousal (Kahneman 1973).

DP4: Minimize the FA's intrusiveness and interference with user's primary tasks.

Following the principle to eliminate distractions before they emerge (DP1), the FA must not introduce additional distractions through its own actions. Abrupt appearance and disappearance of visual elements represent stimuli that compete for the user's attention (Godijn and Theeuwes 2003). Hence, any countermeasure taken by the FA needs to use only subtle changes, for example by hiding interface elements only gradually [DF]. Also, requiring input by the user during a high focus phase (e.g., requiring a decision) constitutes an interruption, as it forces the knowledge worker to divert from his or her primary task (Iqbal and Horvitz 2007). The central aspect of this principle is the automatic engagement and disengagement based on detection of a complex task [DF] – one of the FA's greatest advantage compared to existing distraction countermeasures. We propose a scoring system, adding points for actions indicating a high focus task and subtracting points for actions indicating task completion [DF]. Measurement of corresponding actions may be accomplished through sensory and non-sensory-based parameters, such as keyboard and mouse activity or use of a specific software (Roda and Thomas 2006). Automatic engagement and disengagement is then based on a point threshold.

DP5: Manage each distraction individually according to user-specific rules.

Sometimes distractions contain too important information to rigorously block and delete them, despite disruption: examples include safety-related alerts, notifications about upcoming appointmens and information on events related to the primary task (Arroyo and Selker 2011; Garrett and Danziger 2007). Users' reactions to distractions depend on how they evaluate that a distraction will affect them in accomplishing their goals (Arroyo and Selker 2011). This links to the finding of Garrett and Danziger (2007) that instant messaging related to the primary task may be associated with reduced interruption, if in consequence highly disrupting activities such as reaching out physically to a colleague are reduced. We propose to assign priority levels to incoming distractions based on their urgency and how they relate to the primary task [DF]. Following a user-specific ruleset, the distractions are then assigned one of three actions: delete, delay and show [DF]. *Delete* unnecessary and irrelevant distractions (e.g., spam); *delay* distractions with relevant information to a comprehensive report subsequent to the high focus phase (e.g., email notifications); *show* distractions of imminent urgency (e.g., meeting notifications) or direct relevance to the task at hand. The rules of categorization are malleable and specific to each user to reflect varying preferences and job requirements.

DP6: Adjust to user needs based on artificial intelligence and user feedback.

Maes and Kozierok (1993) suggest incorporating machine learning into assistants like our proposed FA: The assistant learns how to support the knowledge worker by observing objective actions (e.g. keyboard strokes, manual interventions, pulse data [DF]) and by collecting subjective user feedback (through a survey [DF]). Furthermore, machine learning provides customized, adaptive solutions that ensure better user acceptability (Maes and Kozierok 1993). The ability to adapt is crucial for our FA for two main functions: (1) We propose to activate the FA upon detection of a complex task causing high mental workload. Yet, individual user skills and experience play a vital role to what extent a task induces high mental workload or not (Rouse et al. 1993), requiring assessment of each knowledge worker's behavior [DF]. (2) When deploying distraction countermeasures, only a continuous learning process can facilitate understanding how to apply which countermeasure to apply in which situation [DF]. Users concerned with privacy issues require the possibility to opt for data processing restricted to their local machines [DF].

DP7: Empower the user to modify the FA.

Beaudry and Pinsonneault (2005) highlight the importance of perceived control in the adaptation to IT artifacts. Specifically, when a user senses an opportunity in an IT artifact, the feeling of having control over the situation leads users to maximize the benefits and thus effectiveness of the IT artifact. The proposed proactivity and artificial intelligence components of our FA design may reduce the perceived control of the knowledge worker. Hence, the knowledge worker should be provided with possibilities for manual activation, deactivation and intervention. In our design, we propose a simple control panel accessible via a menu bar icon [DF]. Among others, it provides options to manually start/end high focus phases [DF] and options to adjust countermeasures [DF].

Expected Contribution and Next Steps

The contribution of this design science research is the design of an artifact, in that it applies existing knowledge of focus, distraction and attention theory in new and innovative ways for the future of work and, thus, produces significant value to the constituent IS community (Hevner et al. 2004). The design principles advance existing approaches three-fold by incorporating (1) minimal interference of knowledge workers by automatic engagement and disengagement based on automatic detection of when a knowledge worker begins his or her complex task; (2) distraction countermeasures beyond the mere blocking of digital and physical distractions to support the knowledge worker in not processing stimuli that cannot be blocked and (3) the continuous tailoring of the applied distraction countermeasures to the individual knowledge worker by collecting noncompulsory feedback and the modular employment on various available hardware and software.

As our next steps, we intend to use focus groups to refine our design before we commence with the actual implementation. For testing, we will conduct a series of laboratory experiments, in which a treatment and a control group will be performing a range of tasks representative for knowledge workers with varying complexity levels, while simultaneously being exposed to physical and IS-related distractions. We define our success through statistically significant improvements in the variables from phase 2. This testing consists of two phases (Peffers et al. 2007): (1) *demonstration*, where a small group of participants is exposed to one specific productivity context to prove the viability of our design; and (2) *evaluation*, where multiple productivity contexts are tested systematically to prove our design's robustness and effectivity. New design science iteration may be started after each of those phases (Peffers et al. 2007). The final phase covers the communication of our results to researchers as well as practitioners (Peffers et al. 2007).

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