Ubiquitous working: Does where you work affect how you work?
Environmental effects on knowledge work performance

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Summary

Due to modern technological developments, work has become ubiquitous and various mobile, flexible work forms have evolved (i.e., *ubiquitous working*). Besides working in the traditional office, mobile devices also enable working in places that are more associated with leisure than with work (e.g., the living room at home or a garden bench in the park). This applies especially for knowledge workers who require only few material resources in addition to their minds and are therefore independent of a specific location. For example, knowledge workers need a laptop with an Internet connection, a way to communicate with colleagues and customers, or access to data and information to carry out their typical work tasks. Research has shown that information processing and working behaviour are affected by external influences and the environment. Therefore, it is obvious to assume that mobile workers do not show the same work performance while in a typical work environment compared to a typical leisure environment. Using laboratory experiments and field studies, this dissertation investigated whether cognitive performance (i.e., attention and concentration) and decision-making behaviour differ when subjects previously explored either a virtual work (e.g., an office) or leisure environment (e.g., a garden) or were situated in a real work or leisure environment, respectively. Results from eight studies suggest that environments associated with work lead to higher cognitive performance and riskier decisions compared to environments associated with leisure. It may be assumed that factors of the task (e.g., time pressure or environment-task fit) and of the person (e.g., personality traits or mood) affect this relationship. Employers should be aware of these effects when transferring important decisions or tasks that require high concentration to mobile workers. Despite the combination of different, innovative research approaches, methodological limitations have to be discussed and further research is needed before it can finally be clarified how mobile and location-independent work forms such as *ubiquitous working* affect work performance.

Der Begriff *Ubiquitous Working* beschreibt das Phänomen, dass *Arbeit* aufgrund moderner technischer Entwicklungen *allgegenwärtig* geworden ist. Dank mobiler Endgeräte ist es möglich, neben dem eigentlichen Büro auch an Orten zu arbeiten, die eher mit Freizeit als mit Arbeit in Verbindung gebracht werden (z.B. das heimische Wohnzimmer oder eine Gartenbank im Park). Dies gilt vor allem für Wissensarbeitende, die neben ihrem Verstand nur wenige materielle Ressourcen benötigen und damit unabhängig von einem spezifischen Ort sind. Wissensarbeitenden reicht beispielsweise ein Laptop mit Internetverbindung, eine Möglichkeit zur Kommunikation mit Kollegen und Kunden oder der Zugriff auf Informationen und Dateien aus, um typischen Arbeitsaufgaben nachzugehen. Forschung hat gezeigt, dass die Informationsverarbeitung und das Arbeitsverhalten von externen Einflüssen und der Umwelt beeinflusst werden. Daher ist es naheliegend anzunehmen, dass Wissensarbeitende nicht dieselbe Arbeitsleistung zeigen während sie in einer typischen Arbeitsumgebung sind im Vergleich zu einer typischen Freizeitumgebung. Mithilfe von Laborexperimenten und Feldstudien wurde im Rahmen dieser Dissertation untersucht, ob sich kognitive Leistung, wie Aufmerksamkeit und Konzentration, und Entscheidungsverhalten unterscheiden, wenn Versuchspersonen zuvor entweder eine virtuelle Arbeits- (z.B. ein Büro) oder Freizeitumgebung (z.B. einen Garten) erkundet haben oder sich in einer typischen Arbeits- oder Freizeitumgebung aufhalten. Ergebnisse aus acht Studien deuten darauf hin, dass Umgebungen, die mit Arbeit assoziiert werden zu einer höheren kognitiven Leistung und riskanteren Entscheidungen führen. Es kann angenommen werden, dass weitere Faktoren der Aufgabe (z.B. Zeitdruck oder Passung zwischen Umgebung und Aufgabe) und auch der Person (z.B. Persönlichkeitseigenschaften oder Stimmung) diese Beziehung beeinflussen. Arbeitgeber sollten sich dieser Effekte bewusst sein, wenn sie mobil arbeitenden Angestellten wichtige Entscheidungen oder Aufgaben, die hohe Konzentration erfordern, übertragen. Trotz der Kombination verschiedener, innovativer Forschungsansätze müssen methodische Einschränkungen diskutiert werden und weitere Forschung ist nötig bevor abschließend geklärt werden kann, wie sich mobile und ortsunabhängige Arbeitsformen wie *Ubiquitous Working* auf die Arbeitsleistung auswirken.

List of publications in the thesis

Accepted papers

Burmeister, C.P., Moskaliuk, J., & Cress, U. (in press). *Have a look around: The effect of physical environments on risk behaviour in work-related vs. non-work related decision-making tasks. Ergonomics.* doi: 10.1080/00140139.2018.1494308

(Studies 3a and 3b)

Burmeister, C.P., Moskaliuk, J., & Cress, U. (2018a). Ubiquitous working: Do work versus non-work environments affect decision-making and concentration? *Frontiers in Psychology, 9*(310). doi: 10.3389/fpsyg.2018.00310

(Study 2)

Moskaliuk, J., **Burmeister, C.P.**, Landkammer, F., Renner, B., & Cress, U. (2017). Environmental effects on cognition and decision making of knowledge workers. *Journal of Environmental Psychology, 49,* 43-54. doi: 10.1016/j.jenvp.2016.12.001

(Study 1)

Submitted manuscripts

Burmeister, C.P., Moskaliuk, J., & Cress, U. (2018c). *Office versus leisure environments: Effects of surroundings on concentration*. Manuscript submitted for publication.

(Studies 4a and 4b)

Burmeister, C.P., Moskaliuk, J., & Cress, U. (2018d). *Does priming a work versus a leisure concept affect concentration performance?* Manuscript submitted for publication.

(Studies 5a and 5b)

For better readability I refer to the studies in the following text not by citing the corresponding manuscripts but by the study numbers (study 1 - study 5b). The assignment of the manuscripts to the respective study numbers can also be found in Table 1.

Personal contribution

This doctoral thesis was prepared in the form of an integrated accumulation of manuscripts (cumulative dissertation). All accepted papers (Appendix A) and submitted manuscripts (Appendix B) in this dissertation were made in collaboration with other researchers. The official form for information about personal contribution can be found in Appendix C “Declaration of personal contribution”.

Introduction

Ubiquitous working

Since the last decades it is no longer an uncommon scene: As soon as you have taken a seat on the plane, the first ones open their laptops and start working whereas others relax and enjoy their holiday mood. The same situation occurs in the park; while some people just have a rest in the fresh air, others are on the phone making important professional decisions. This current phenomenon of being digitally inter-connected with your work anywhere and anytime has allowed work to become ubiquitous (Chen & Nath, 2005; Davis, 2002; Su & Mark, 2008). Since communication technologies became mobile and ever more flexible, different forms of *ubiquitous working* evolved for example known as *telework* or *mobile*, *multi-locational*, *remote*, *flexible*, or *virtual* work (e.g., Bailey & Kurland, 2002; Kurland & Bailey, 1999; Lönnblad & Vartiainen, 2012). Mobile devices such as notebooks, smartphones, or tablets make it possible to constantly access data and other information while being able to communicate with supervisors, colleagues, or clients. Therefore some work can be done from anywhere in the world as long as resources such as electricity or Internet access are available. Mobile work, which began with the home office, is now completely detached from office-like, fixed environments (Messenger & Gschwind, 2015). Many employees no longer work in only one location such as the traditional office with well-organized work stations, desktop computers, and writing tables, but wherever they happen to be at the moment (e.g., Chen & Nath, 2005; Hislop & Axtell, 2007; Koroma, Hyrkkänen, & Vartiainen, 2014; Su & Mark, 2008; Vartiainen & Hyrkkänen, 2010). Considering that, research regarding ‘how to design the perfect office’ (e.g., Aries, Veitch, & Newsham, 2010; Ceylan, Dul, & Aytac, 2008; Stone, 2001) seems insufficient and concepts of performing, supervising, and organizing work have to be re-examined due to this fundamental change of working environments (Halford, 2005).

A great body of research already investigated assets and drawbacks of mobile work forms primarily referring to management factors such as financial issues or supervision, and social and personal aspects such as job satisfaction or work-life balance (e.g., Davis, 2002; Kurland & Bailey, 1999). Examples include that mobile work saves commuting time and office spaces, enables global cooperation and allows a more autonomous and flexible organisation of private and work life. But mobile workers might also suffer from work intensification or lacking borders between work and private life and supervisors have fewer possibilities to manage and control their employees (e.g., Bailey & Kurland, 2002; Baines, 2002; Chesley, 2014; Demerouti, Derks, ten Brummelhuis, & Bakker, 2014; Kelliher & Anderson, 2010; Messenger & Gschwind, 2015; Sørensen & Gibson, 2004; ter Hoeven & van Zoonen, 2015).

However, up to now, consequences of mobile work on productivity and work behaviour are unclear (e.g., Bailey & Kurland, 2002) even though employees' work performance is decisive for the success and survival of a company. Furthermore, to my knowledge, no research has compared effects of differing environments on work performance apart from traditional office situations. In my dissertation project I conducted eight consecutive studies to investigate whether and how performance and behaviour differ, depending on whether the same piece of work is conducted in a typical workplace or a location that was not originally intended for work. I will summarise the theoretical background, methods, and general findings of these studies. Detailed descriptions and information can be found in the manuscripts attached as Appendix A and B (see Table 1 for an overview). In the following I will present the theoretical components on which my assumptions and hypotheses are based including research in the areas of environmental psychology, cognitive priming, and concept theories. Further, I will explain how work performance has been defined.

Environmental effects on work performance

As already mentioned, the stereotypical work environment for knowledge workers was a single room or a cubicle in an open-plan office inside a company building, equipped with workstations and desks for many years (e.g., Kidd, 1994). Mobile work practices now allow hotel lobbies, the living room at home, or the park and the thriving garden to become a temporary work environment although these environments were originally not conceptualised to be places for working. A great body of research has already shown that information processing and behaviour is affected by external surroundings (detailed below). Therefore, I derived the assumption that different environments, each entailing specific characteristics, should affect work performance. In the following I elaborate on two research lines that support this assumption. On the one hand, research that relates to the influence of concrete physical features of environments on various aspects of work behaviour and work performance and on the other hand, research that more generally investigates the process of how information processing and performance is influenced, a branch of research that is closely linked to priming research.

Physical features affect work behaviour.

For decades, researchers and employers have been searching for the perfect office design to maximize employee productivity and satisfaction. Especially in creativity research, design guidelines have emerged to foster employees' creativity and innovativeness (e.g., Alencar & Bruno-Faria, 1997; Amabile, Conti, Coon, Lazenby, & Herron, 1996; Dul & Ceylan, 2011; Dul, Ceylan, & Jaspers, 2011), and it was investigated how environments can contribute to employees' satisfaction (e.g., Vischer, 2007, 2008). A long list of physical features have been identified to influence work performance and behaviour: Examples include spatial configuration (e.g., Shalley, Zhou, & Oldham, 2004), interior design (e.g., Ceylan et al., 2008; McCoy & Evans, 2002), nature views (e.g., Lee, Williams, Sargent, Williams, & Johnson, 2015; Tennessen & Cimprich, 1995) and window access (e.g., Aries et al., 2010; Stone & Irvine, 1994), lightning conditions (e.g., Chellappa et al., 2011; Steidle & Werth, 2013; Steidle, Werth, & Hanke, 2011), perceived comfort within the workspace (e.g., Vischer, 2007, 2008), noise (e.g., Hygge & Knez, 2001; Varjo et al., 2015), ventilation (e.g., Seppanen, Fisk, & Lei, 2005) or temperature (e.g., Seppanen, Fisk, & Lei, 2006). All these physical features differ in distinct environments, to compare for example a typical work surrounding (e.g., artificial light and stale air in a compact office) with a leisure environment (e.g., natural light and fresh air in a spacious park), and in turn, behaviour and performance in these environments can be expected to diverge.

Effects of cognitive priming on information processing.

Besides these concrete, physical characteristics of environments, more abstract factors have been shown to influence cognitive processing as well. Priming research has identified another long list of influencing factors on work performance and behaviour: Examples are adjectives, traits, or stereotypes that are associated with a certain behaviour (e.g., Bargh & Williams, 2006; Dijksterhuis & van Knippenberg, 1998; Förster, Friedman, Butterbach, & Sassenberg, 2005), surroundings that are related to normative habits (e.g., Aarts & Dijksterhuis, 2003), mundane physical objects that are specific for a situation (e.g., Kay, Wheeler, Bargh, & Ross, 2004; Rutchick, Slepian, & Ferris, 2010; Slepian, Weisbuch, Rutchick, Newman, & Ambady, 2010), or well-known brands that are associated with certain behaviours (e.g., Fitzsimons, Chartrand, & Fitzsimons, 2008). Because specific features of different environments might act like primes and therefore shape behaviour in diverging directions, this is another indication to expect performance differences in varying environments.

Activation of concepts

Stimuli of various kinds have been shown to affect behaviour or performance. Cognitive schema theories (e.g., Fiske, 2000; Fiske & Linville, 1980) or related concept theories (e.g., Barsalou, 1982) offer explanations for these effects. A cognitive schema is described as a “cognitive structure that represents knowledge about a concept or type of stimulus, including its attributes and the relations among those attributes […]” (Fiske, 2000, p.158). Cognitive schemas guide information processing and behaviour and are learned in the course of prior experiences and continuous repetition (e.g., Cohen & Ebbesen, 1979; Fiske, 2000; Fiske & Linville, 1980; Wirtz, 2013). Barsalou (e.g., 1982, 1999, 2002) refers to these mental representations of knowledge as concepts. Concepts contain information about all elements and stimuli in the world, including related expectancies, attitudes, norms, experiences, as well as associated actions. Therefore, concepts help to orient oneself in the world: As soon as a concept is activated, all relevant, conjointly stored knowledge is reactivated and guides adequate information selection, cognitive processing, or offers appropriate scripts about adequate behaviour (e.g., Abelson, 1976, 1981; Barsalou, 1982; Barsalou & Sewell, 1985). According to grounded or embodied cognition research, these mental representations also incorporate situational information (Barsalou, 1999, 2002, 2003; Yeh & Barsalou, 2006). As cognition always happens in a situation within a specific environment, external stimuli are encoded as well, which are therefore stored and reactivated together with the formed concept (e.g., Barsalou, 2010; Prinz & Barsalou, 2000; Wilson, 2002). Situation conceptualization theory (e.g., Barsalou, 2016) describes this process in the following way: In the course of life, individuals learn that some objects, persons, activities, or behaviours always occur in the same or in similar environments or situations. After some time, this knowledge will be entrenched and when such an environment or situation arises in the future, these objects, persons, activities, or behaviours will automatically come to mind (e.g., Barsalou, 2005, 2016; Yeh & Barsalou, 2006).

Work concepts versus leisure concepts.

Based on these research lines, I derived the assumption that the same process occurs in the everyday working life: I assume, that due to prior experiences, individuals have formed a distinct concept about work including all information about how to behave at the workplace (e.g., to act professionally or to be productive), about what kinds of activities or tasks can be expected (e.g., to work on tasks that require great concentration or to make vocational decisions), and about typical environments in which work is usually conducted (e.g., in an office-like interior offering work space, materials, and resources such as desks, computers, or Internet access). I assume that this *work concept* is continuously enriched and consolidated and can be reactivated by each kind of stimulus that is associated to it, for example, by simply entering a typical office environment. In practical terms, for knowledge workers this means that, for example, once they enter an office, they should be reminded of their typical work tasks (e.g., to work with great concentration and to make decisions) and required cognitive resources should automatically be activated to facilitate these behaviours. In contrast, other environments that are not associated with working (e.g., a park, a café, or the homely living room) should activate a different concept, for example a *leisure concept*. In these kinds of environments individuals usually relax, socialize, or pursue their hobbies. Knowledge, information and expectancies stored within leisure concepts should therefore be geared towards a different goal (e.g., to avoid strain and to go easy on resources) compared to work-related ones and should in turn not facilitate performance in work-related activities.

Mobile work is mainly knowledge work

Especially knowledge work is predestined for location-independent, mobile work as it requires a minimum of technical resources and relies on great autonomy and self-responsibility (e.g., Bailey & Kurland, 2002; Drucker, 1999; Lönnblad & Vartiainen, 2012; Van Yperen, Rietzschel, & De Jonge, 2014). Knowledge workers primarily need their minds to work and are not dependent on machines or materials in a way as, for example, manual workers are (Kidd, 1994). Knowledge workers merely need a mobile device and access to the Internet to carry out most of their work activities (e.g., Koroma et al., 2014; Sørensen & Gibson, 2004). In developed countries the largest group in the workforce consists of knowledge workers (Drucker, 1999) whose main tasks are to organise, to create knowledge and to gather, analyse and use information in order to plan and decide beneficially and profitably (Davis, 2002; Drucker, 1999; Kelloway & Barling, 2000; Ramirez & Nembhard, 2004). With these tasks, knowledge workers have a crucial role and the success of a company depends on their productivity and work performance to a large extent.

Knowledge work performance.

Because the outcome of typical knowledge work tasks (e.g., a solution for a problem or a professional decision) is seldom tangible and cannot be measured in quantitative terms (e.g., number of produced units) for the most part, it is difficult to assess knowledge work performance (Drucker, 1999; Ramirez & Nembhard, 2004; Reinhardt, Schmidt, Sloep, & Drachsler, 2011). Up to now no generally valid method to measure knowledge work performance is established (Ramirez & Nembhard, 2004) which is why I measured two basic cognitive activities that underlie the already mentioned knowledge work tasks as indicators for knowledge work performance: Cognitive performance and decision-making behaviour.

I measured cognitive performance in terms of attention and concentration as these qualities are fundamental prerequisites to guarantee successful reasoning and learning, to be able to solve problems, to control actions, or to make decisions (Duval, 2011; Schmidt, 1995; Wirtz, 2013). Attention is required to guide efficient information processing by selecting relevant information while suppressing irrelevant stimuli whereas concentration is to be completely immersed in a thought or an action (e.g., Castle & Buckler, 2009).

Making decisions involves a row of complex actions and various information has to be processed, evaluated, and weighed against each other (e.g., Cokely & Kelley, 2009; Dohmen, Falk, Huffman, & Sunde, 2010; Newell & Bröder, 2008). Especially top-level employees are required to deal well with risks in organizational decisions in order to contribute to the company’s success (e.g., Busenitz, 1999; Busenitz & Barney, 1997; Damodaran, 2007; MacCrimmon & Wehrung, 1988; March & Shapira, 1987; Stewart & Roth, 2001). Decision making-behaviour is a frequently investigated research area and has been shown to be affected by various factors, for example by individual aspects such as emotional states (e.g., Isen & Patrick, 1983) or personality (e.g., Nicholson, Soane, Fenton-O’Creevy, & Willman, 2005; Weinstein, 1969; Zuckerman & Kuhlman, 2000), by the framing or the context of the decision (e.g., Arkes, Herren, & Isen, 1988; Brewer & Kramer, 1986; Kühberger, 1998; Levin, Schneider, & Gaeth, 1998; Payne, 1982; Shepherd & Rudd, 2014), or the decision domain (e.g., Jackson, Hourany, & Vidmar, 1972; Kogan & Wallach, 1964; Nicholson et al., 2005). For example, people tend to make riskier work decisions than private decisions, because the responsibility at work does not have to be borne alone (e.g., MacCrimmon & Wehrung, 1988; March & Shapira, 1987).

Objectives and expected output of the thesis

Research question

Although mobile work forms, especially for knowledge work, are already common practice, there is a lack of research regarding the productivity of this ongoing development. The aim of my dissertation project is to close this research gap and to answer the research question: “Does *where* you work affect *how* you work?”

Based on available literature, I derive the assumption that environments have the potential to affect behaviour and performance. I assume that a typical work environment (e.g., the office) should facilitate performance in typical knowledge work activities (e.g., to work with great concentration or to take risks in professional decisions). Because over a long period individuals have framed a *work concept* by associating typical work environments with typical work behaviours, required resources, and expectable activities and tasks. This work concept should in turn facilitate performance in these typical work tasks once it is activated by a related stimulus, for example, by the associated environment. In contrast, a typical leisure environment (e.g., a garden or park) should activate a concept associated with leisure (e.g., to relax and to preserve cognitive resources), which should not facilitate performance in work-related activities. Because various factors have already been identified to affect behaviour and performance, I examine several influencing factors (e.g., characteristics of the task or of the individual) with regard to their potential effects on the relationship between environment and work performance.

Based on the findings, I derived practical implications to ensure that ubiquitous working, working mobile and location-independent, can be applied efficiently and advantageously and to make employers and employees aware of potential challenges.

Overview of methods

In the following I will give a brief overlook of methods used in my dissertation studies, including manipulation of work environments, activation of concepts, assessment of work performance, and other potential influences. Specific details on procedures, methods, and materials regarding all assessed variables can be found in the respective manuscripts (references to the relevant studies are provided in parentheses). An overview of all studies and corresponding manuscripts can be found in Table 1. The chapter *Summary of studies* outlines how the studies are built on each other.

Manipulation of work environments.

As already mentioned, a row of specific factors within environments have been identified to influence performance and behaviour (e.g., lightning, temperature, ventilation). This complicates research dealing with environmental effects and makes it difficult to extract or identify the contribution of a single one of these many influencing factors. To curb this difficulty, I have used a method that makes it possible to keep different environments constant with respect to a number of situational variables: Recreating typical work and typical leisure environments by means of virtual realities. By having invited subjects to a laboratory I was able to control various confounders (such as noise, comfort, temperature and light conditions) because the participants' situations differed only in terms of the virtual environment (work or leisure). Virtual realities have already been used repeatedly in different areas of psychological research and are becoming more and more important because they can reconstruct realistic situations while offering high controllability (e.g., Blascovich et al., 2002; Cho et al., 2002; Cohen-Hatton & Honey, 2015; Klinger et al., 2005; Slater, 2009). I used different alterations of virtual realities in the course of my studies with varying dimensions of immersion and realism (studies 1, 2, 3a, 4a). Participants freely explored the virtual environments (either a detailed, realistic simulation of an office or garden scenery) and were asked to imagine that they actually were in this place and to envision how they would feel and spend their time there.

This method allows investigating performance differences in a highly controlled experimental environment but it also has a disadvantage, since a laboratory experiment is not an ecologically valid everyday situation. To counteract this problem, I additionally conducted online assessments in the field (studies 3b, 4b) that repeated the laboratory experiments with the same materials and tests. Participants were sent a survey link, which they should open either in their real work environment (e.g., their office) or in their typical leisure environment (e.g., on their balcony). Extensive manipulation checks were administered to verify that assessments were conducted in the intended environments. I compared results of laboratory and field studies to draw conclusions based on both methodologies.

Activation of concepts.

A mental process such as the activation of concepts and mental representations can, inherently, not be assessed or investigated directly. Therefore, I used different indicators in the course of my studies to measure the activation of work versus leisure concepts. In an allegedly unrelated free association task I asked participants to write down as many words or phrases that sprang to mind within a restricted time (studies 3a, 3b). I assumed that an active work concept should implicitly produce more words or phrases that are associated with work compared to an active leisure concept that should produce more leisure-related words. As another indicator of concept activation I used self-reports and asked participants to rate on a scale from ‘not at all’ to ‘very much’ whether they felt like they are in a work mode or a leisure mode at the moment (studies 4b, 5a, 5b). In studies 5a and 5b I further investigated the assumption and disentangled activated concepts from actual environments by using a priming approach. By means of a well-established priming task (scrambled sentence test, e.g., Bargh, Chen, & Burrows, 1996) I intended to deliberately activate either a work concept or a leisure concept by confronting participants with work-related or leisure related words, respectively.

Work performance.

Doing work in a highly concentrated manner and making decisions are essential work activities that are crucial for organizational success (e.g., Busenitz, 1999; Busenitz & Barney, 1997; Kelloway & Barling, 2000; MacCrimmon & Wehrung, 1988; Ramirez & Nembhard, 2004; Reinhardt et al., 2011). Relying on these performance criteria allowed me to measure work performance in an objective and standardized way by means of well-established performance tests.

In my dissertation studies I measured attention (study 1) and concentration (studies 1, 2, 4a, 4b, 5a, 5b) as indicators of cognitive performance. I used two standardized tests: A lexical decision task (LDT; e.g., Fischler, 1977; Fisk, Cooper, Hertzog, Batsakes, & Mead, 1996; McCann, Besner, & Davelaar, 1988; study 1) to measure attention and the Psychomeda Konzentrationstest (concentration task, KONT-P; Satow, 2011; studies 1, 2, 4a, 4b, 5a, 5b) to measure concentration in terms of accuracy, efficiency, speed, as well as accuracy increase and speed increase in the course of the test. In addition, I asked participants to self-evaluate their concentration in view of the fact that subjectively perceived and objectively assessed concentration performance might diverge (e.g., Hill, Ferris, & Märtinson, 2003; studies 4a, 4b, 5a, 5b).

I used different approaches to assess decision-making behaviour because research indicates that decision making is multidimensional and that the method of assessment might affect the outcome (Kogan & Wallach, 1967; Slovic, 1964). I used the Holt Laury Lottery (HLL), a dual-choice task dealing with financial decisions on the stock market (Holt & Laury, 2002; studies 1, 2), the Balloon Analogue Risk Task (BART), a computerized risk task assessing how long one dares to inflate a balloon just before it bursts (Lejuez et al., 2002; study 2) and situation dilemma scenarios including hypothetical life decisions related to work or private risks (Jackson et al., 1972; Kogan & Wallach, 1964; studies 3a, 3b).

Potential influential factors.

In the course of my literature research I came across several factors that can be suspected to affect the relationship between environmental effects, and work behaviour and performance. These include characteristics of the tasks such as the task context or work demands like time pressure as well as individual characteristics such as current mood or personality traits. I have taken these factors into account and investigated them in several studies I briefly mention below.

Task characteristics.

Research has shown that there is no generally superior surrounding but that different environments are beneficial for certain task types or activities (Elsbach & Pratt, 2007). For example, stimulating environments foster performance in routine tasks whereas little distracting environments enhance performance in complex tasks (e.g., Block & Stokes, 1989; Larsen, Adams, Deal, Kweon, & Tyler, 1998; Stone & English, 1998; Stone & Irvine, 1994). Requirements for a task and resources supplied by the environment have to match in order to guarantee optimal task performance (e.g., Elsbach & Pratt, 2007; Gerdenitsch, Korunka, & Hertel, 2017; Wohlers, Hartner-Tiefenthaler, & Hertel, 2017). To investigate the potential role of a fit between environment and task, the task context (work vs. private decisions) was systematically varied in studies 3a and 3b: In a typical work environment participants were asked to make either decisions that are related to work (fit) or to their private lives (no fit). The same procedure was conducted for a typical leisure environment (work-related (no fit) versus private decisions (fit)).

A typical work demand in daily work routine is doing tasks under time pressure. Wilson (2002) suggested that information processing is affected by time constraints and a row of findings show that time pressure also influences decision making (e.g., Kelly & Karau, 1999; Maule, Hockey, & Bdzola, 2000; Suri & Monroe, 2003). In study 2, time pressure was manipulated (time pressure present versus time pressure absent) by means of verbal prompts and the presence (or absence) of a ticking egg-timer.

Individual characteristics.

Various individual aspects can affect work performance and therefore it is obvious to assume that some might also play a role in the relationship between environmental effects and performance or behaviour. For example, extensive research suggests that current mood affects information processing and performance (e.g., Clore, Gasper, & Garvin, 2001; George & Zhou, 2007; Hirt, Levine, McDonald, Melton, & Martin, 1997; Martin, Ward, Achee, & Wyer, 1993) as well as decision making (e.g., Isen & Patrick, 1983; Lerner, Li, Valdesolo, & Kassam, 2015; Mittal & Ross, 1998; Raghunathan & Pham, 1999; Yuen & Lee, 2003). Individuals might interpret their current mood as a signal of the valence of their current surroundings. Negative mood might be perceived to indicate a problematic environment whereas positive mood might signal a benign environment, which in turn affects processing styles and behaviour (e.g., Chartrand, van Baaren, & Bargh, 2006; Dolan, 2002; Isen & Patrick, 1983; Mittal & Ross, 1998; Schwarz, 2000, 2001; Yuen & Lee, 2003). In addition, aspects within the environments themselves have the potential to cause mood states and then again influence behaviour (e.g., affective events theory; Ashkanasy, Ayoko, & Jehn, 2014; Weiss & Russell Cropanzano, 1996). In studies 3a and 3b I measured mood by means of a standardized questionnaire (Aktuelle Stimmungs Skala ASTS, Dalbert, 1992).

Of course there are many other individual characteristics that play a major role when investigating work performance or behaviour. As representatives I chose to further investigate the following personality traits in study 1: Achievement motivation (assessed by the Leistungsmotivationsinventar LMI-K; Schuler, Prochaska, & Frintrup, 2001), numerical intelligence (assessed by the Intelligenzstrukturtest I-S-T 2000R, Liepmann, Beauducel, Brocke, & Amthauer, 2007), and perceived freedom from constraints assessed in terms of assertiveness and perceived self-regulation (Jacobs & Scholl, 2005; Ryan & Deci, 2000; as described by Steidle & Werth, 2013). In addition, I conducted studies 4a and 4b with a Within-Subjects-Design to be able to control for individual differences and to investigate intrapersonal performance differences in work and leisure environments.

Summary of studies

To answer my research question, I have conducted a series of studies investigating the assumptions from different perspectives using varying methods. In study 1 I compared cognitive performance in terms of attention and concentration, as well as decision making between two groups in the laboratory: One group explored a virtual office, whereas the other group explored a virtual garden preceding to the performance tests. I hypothesised that exploring the virtual office would enhance performance compared to the virtual leisure environment. Results spoke in favour of the hypotheses but were only small in size. In order to enlarge effect sizes, I repeated the study design but further refined the environment manipulation to make it more immersive. Participants in study 2 (laboratory) did not only explore the virtual environments on the computer screen, but the environments were projected to the wall in larger size and remained during the course of the experiment. In addition, I manipulated time pressure to investigate potential moderating effects on concentration and decision making. However, results revealed that time pressure was not influential, therefore, I conducted studies 3a and 3b investigating another potential moderating factor: Task context. In studies 3a and 3b I focused on measuring decision making but used a different assessment than in the preceding studies: Participants were asked to make decisions that are either related to work or to their private life. In study 3a I again manipulated environment by virtual realities in the laboratory but with a different technology using a different virtual design with the goal to strengthen immersion. Additionally, I replicated study 3a (with the same materials, design, and procedure) in the field using an online assessment (study 3b). Instead of manipulating the environment with virtual realities, I asked participants to conduct the experiment either within their real work environment or within their real leisure environment. The goal of a combination of laboratory and field methods was to increase ecological validity and to examine whether results of the laboratory study can be transferred to the field. I conducted studies 4a and 4b using a similar approach, with study 4a set up in the laboratory (virtual environments) and study 4b set up in the field (real environments). Compared to the preceding studies (1-3b), I changed the design of studies 4a and 4b from a between-subjects design to a within-subjects design. By doing this, I intended to control for individual effects as studies 1-3b revealed, that a row of individual characteristics (e.g., achievement motivation, numerical intelligence, or mood) might moderate the effect of environments on performance. In studies 4a and 4b I focused on measuring concentration and included a subjective measure of concentration in addition to the previously used objective concentration task. Studies 1- 4b build on each other with the goal to further encircle the investigation of environmental effects on knowledge work performance. In each study I further refined the design of the environment manipulation, by for example adapting the design of the virtual environments or improving manipulation checks in the field experiments. In addition, I implemented changes in the assessment of dependent variables due to lessons learned in the previous studies (e.g., by adapting the measures of decision making). Studies 5a and 5b included a slightly different approach: Instead of manipulating the environment, I intended to directly activate either a work or a leisure concept by means of a priming task detached from the environment. Again, I investigated potential effects of active concepts on objective and subjective concentration.

Table 1 provides an overview of studies, design, dependent variables and hypotheses. Each study is described in further detail in a separate manuscript (information about related manuscripts in Table 1).

Table 1

Overview of reported studies with assignment of manuscripts to number of study (Nr.), design, independent variables (IV), environment manipulation (Manipulation), dependent variables (DV), and hypotheses.

Manuscript	Nr.	Design	IV	Manipulation	DV	Hypotheses*
Moskaliuk, Burmeister, Landkammer, Renner, & Cress (2017)	1	2 x Between-subjects	Environment (work-associated vs. non-work-associated)	Laboratory: Exploration of virtual realities (virtual office/virtual garden)	Attention (LDT[1]) Decision making (HLL[2]) Concentration (KONT-P[3])	H1: Attention is higher in a work-associated environment compared to a non-work-associated environment. (+) H2: Concentration is higher in a work-associated environment compared to a non-work-associated environment. (+) H3: Decision making is riskier in a work-associated environment compared to a non-work-associated environment. (+)
Burmeister, Moskaliuk, & Cress (2018a)	2	2 x 2 Between-subjects	Environment (work-associated vs. non-work-associated) Time pressure (time pressure vs. no time pressure)	Laboratory: Exploration of virtual realities (virtual office/virtual garden)	Decision making (BART[4] & HLL[2]) Concentration (KONT-P[3])	H1a: Decision making is riskier in a work-associated environment compared to a non-work-associated environment. (+) H1b: Concentration is higher in a work-associated environment compared to a non-work-associated environment. (+) H2: The enhancing effect of the work-associated environment on decision making and concentration should be more pronounced in conditions with time pressure compared to conditions with no time pressure. (-)
Burmeister, Moskaliuk, & Cress (2018b)	3a	2 x 2 Between-subjects	Environment (work-associated vs. non-work-associated)	Laboratory: Exploration of virtual realities (virtual office/virtual garden)	Decision making (HSD[5])	H1a: Decision making is riskier in a work-associated environment compared to a non-work-associated environment when the decision making task is work-related. (-) H1b: Decision making is less risky in a work-associated environment compared to a non-work-associated environment when the decision making task is non-work-related. (-)
	3b		Decision task context (work-related vs. non-work-related)	Field: Visit real, individual environments (work -/leisure-related)		

Burmeister, Moskaliuk, & Cress (2018c)	4a	2 x Within-subjects	Environment (work-associated vs. non-work-associated)	Laboratory: Exploration of virtual realities (virtual office/virtual garden)	Objective concentration (KONT-P3) Subjective concentration (self-report rating scale)	*H1a:* Objective concentration is higher in a work-associated environment compared to a non-work-associated environment. (+) *H1b:* Subjective concentration is higher in a work-associated environment compared to a non-work-associated environment. (-)
	4b			Field: Visit real, individual environments (work-/leisure-related)	See study 4a Schema activation (self-report rating scale)	H2a: See study 4a, H1a (+) H2b: See study 4a, H1b (+) H2c: Activation of a work-related schema is higher within the work-associated environment compared to the non-work-associated environment (-)
Burmeister, Moskaliuk, & Cress (2018d)	5a	2 x 2 Between-subjects	Word priming (work-related vs. non-work-related)	Laboratory: No environment manipulation	Activation of work and leisure mode (self-report rating scale) Objective concen-tration (KONT-P[3])	H1: Activation of a work mode is higher in conditions in which participants were primed with work-related compared to leisure-related words (and reversely, activation of a leisure mode is higher in conditions with leisure-related compared to work-related words). (-) H2: Objective concentration is higher in conditions in which participants were primed with work-related compared to leisure-related words. (-)
	5b			Field: No environment manipulation	Subjective concen-tration (self-report rating scale)	H3: Subjective concentration is higher in conditions in which participants were primed with work-related compared to leisure-related words. (-)

Note. *Results support the hypothesis (+) or results do not support the hypothesis (-). [1]Lexical decision task, [2] Holt Laury Lottery, [3] Psychomeda Konzentrationstest, [4] Balloon Analogue Risk Task, [5] Hypothetical situation dilemmas.

Results and discussion

Environmental effects on cognitive performance

In studies 1, 2, 4a, and 4b, I assumed that being in an environment that is typically associated with work (e.g., an office) would enhance cognitive performance in terms of attention (study 1) and concentration (studies 1, 2, 4a, 4b) compared to environments that are associated with leisure (e.g., a garden or the living room at home). Across the studies I found partial support for these assumptions.

In study 1 participants were marginally significantly faster in a lexical decision task (i.e., showed greater attention) after exploring a virtual office environment compared to a virtual leisure environment. Additionally, participants showed greater concentration in the virtual office environment condition compared to the virtual leisure environment condition with regard to several sub-measures of the concentration test KONT-P. For example, participants were significantly more accurate, marginally more efficient, and marginally faster. In addition, participants showed greater speed increase during the course of the concentration task indicating less careful task completion in the leisure condition compared to the work condition. In study 2 I found significant differences between environments for performance in the concentration test KONT-P only for one sub-measure: Participants showed higher accuracy increase after exploring the virtual office environment compared to participants who explored the virtual leisure environment. In study 4a participants showed significantly higher efficiency and significantly higher accuracy increase in the KONT-P after exploring the virtual office compared to exploring the virtual leisure environment. In study 4b participants showed significantly higher accuracy and marginally higher speed when being in their office environment compared to their leisure environment. Besides the assessment of objective concentration by means of the standardized KONT-P, I measured subjective concentration in terms of a self-report in studies 4a and 4b: Subjective performance did not differ between work and leisure environments in study 4a, but in study 4b participants reported higher subjective concentration when being in their office environment compared to their leisure environment.

To sum up, I found small to moderate effect sizes for attention (η^2 part. = 0.05) and accuracy, speed, efficiency, accuracy increase, subjective concentration (between d = -0.58 and d = -0.15) and speed increase (d = 0.77) in the concentration task. However, effects were not stable across all studies for the same sub-measures. For example, in each case only two out of four studies showed significant differences in accuracy, speed, efficiency, and accuracy increase, only one of the four studies showed a significant difference in speed increase, and only one of two studies revealed significant effects for subjective concentration. Since attention was only measured in Study 1, no statement can be made about the stability of this effect. However, although some differences were only marginally significant or not stable for single sub-measures, findings across all studies pointed in the assumed direction: In each case, attention and concentration measures were higher in the work environment conditions compared to the non-work environment conditions.

Environmental effects on decision making

In studies 1, 2, 3a, and 3b, I assumed that being in an environment that is typically associated with work (e.g., an office) would lead to riskier decision-making behaviour compared to environments that are not associated with work (e.g., a garden or the living room at home). Across the studies I found partial support for this assumption.

In study 1 participants showed significantly less risk aversion (thus riskier decision-making behaviour) in the Holt Laury Lottery after exploring a virtual office environment compared to participants who explored a virtual leisure environment. In study 2 this main effect of environment condition (work vs. leisure) on decision making was only marginally significant but still pointed in the same direction: Participants showed riskier decision-making behaviour in the Holt Laury Lottery after exploring a virtual office environment compared to a virtual leisure environment. In studies 3a and 3b I investigated whether a fit of the environment (associated with work vs. non-work) and the decision making context (risks related to work vs. non-work) would lead to riskier decision making in hypothetical situation dilemmas. I hypothesised that exploring a virtual office environment (study 3a) or being in a real office environment (study 3b) would lead to riskier decision making when risks are related to work, and exploring a virtual leisure environment (study 3a) or being in a real leisure environment (study 3b) would lead to riskier decision making when risks are related to private life. Results did not support this hypothesis, decision-making behaviour in either work-related or non-work-related situation dilemmas did not differ between work and non-work environments. However, if mood was included as a moderator, hypotheses were partially supported. In study 3a participants who experienced negative mood states showed riskier decision making in work-related situation dilemmas after exploring a work-associated environment compared to participants who explored a leisure-associated environment. I found a similar result in study 3b for non-work conditions; participants who experienced negative mood states showed riskier decision making in non-work-related situation dilemmas when being surrounded by a non-work-associated environment.

To sum up, I found small to moderate effect sizes for decision making (d = -0.57 to d = -0.35). This effect was stable when decision-making behaviour was measured with the Holt Laury Lottery, but not with the Balloon Analogue Risk Task (BART) or with hypothetical situation dilemmas. Again, findings across all studies pointed in the assumed direction: Decision making was riskier in the work environment conditions compared to the non-work environment conditions.

Activation of concepts

As explained in the introduction, I assumed that effects of the environment on cognitive performance and decision-making behaviour are based on automatic activations of associated concepts. I assumed that a work environment activates a concept that is associated with work, whereas a leisure environment activates a leisure-associated concept. Since concept activation cannot be measured directly, I assessed the process in studies 3a, 3b, 4b, 5a, and 5b in an indirect way by means of different methods.

Several findings gave support for my assumptions. In studies 3a and 3b participants reported significantly more work-related words in a free association task in work environment conditions (compared to leisure environments) and more leisure-related words in leisure environment conditions (compared to work environments). In study 4b participants reported higher activation of a work concept in a self-report rating when being in a work environment (compared to a leisure environment) and higher activation of a leisure concept when being in a leisure environment (compared to a work environment).

In studies 5a and 5b I used a different method to activate a work or a leisure concept. Instead of manipulating the real environment, I intended to prime either a work or a leisure concept by means of a well-established word priming task, presenting participants either work-related or leisure-related words. However, results showed that presenting work-related words did not activate a work concept, as well as leisure-related words did not activate a leisure concept. In addition, the word priming did not affect subsequent concentration. These findings indicate that a simple word priming task is neither sufficient to activate a work or a leisure concept nor to affect cognitive performance in a way, virtual or real work and leisure environments do.

Moderators

In the course of my experiments I included several control variables to examine potential moderating effects on the relationship between environment and cognitive performance and decision making. I investigated characteristics of the task such as task context (studies 3a and 3b) and time pressure (study 2) as a typical work demand, as well as individual characteristics such as moods (studies 3a and 3b) or personality traits (achievement motivation, numerical intelligence, and perceived freedom from constraints in study 1).

As already reported, a fit of the task context (work-related vs. non-work-related decision) and the environment (work vs. non-work) did enhance risky decision making behaviour in studies 3a and 3b. Work-related decisions were more risky in work-associated environments, whereas non-work-related decisions were more risky in non-work-associated environments. However, this holds only true for participants having experienced negative mood states: Only participants experiencing high sad, high desperate, or low positive mood were affected by the fit between environment and task context. Participants who experienced balanced or relatively positive moods were not affected by the environment neither for work- nor for non-work-related decisions.

I investigated time pressure as a representative of a typical demand in work life. I assumed that working under time pressure would interact with environmental effects with regard to concentration and decision making. I found several main effects of time pressure on concentration that were not surprising: Participants were more accurate in conditions without time pressure and faster in conditions with time pressure. However, I did not find any interaction effects of environment and time pressure, neither regarding concentration nor decision making (study 2).

I found several interaction effects of environment and the personality traits I investigated in study 1. Environment and numerical intelligence did show a significant interaction with regard to concentration: Higher numerical intelligence dampened the enhancing effect of the environment on accuracy and efficiency in the concentration test KONT-P. Results suggested that participants with lower numerical intelligence benefitted more from the work environment regarding their concentration, whereas participants with higher numerical intelligence performed as efficiently and accurately in the work environment as in the non-work environment. In addition, I found significant interactions of environment and achievement motivation with regard to decision making: Higher achievement motivation strengthened the enhancing effect of work environment on risky decision making. Additionally, I found a significant interaction of environment and freedom from constraints regarding decision making, namely, greater freedom from constraints strengthened the effect of work environment on risky decision making. Participants with higher achievement motivation and higher perceived freedom from constraints benefitted more from the work environment whereas participants with lower expressions of these traits were less affected by environments.

To sum up, a fit between the environment and the task context together with negative moods, as well as high achievement motivation and great freedom from constraints did affect the relationship between environment and decision making. Numerical intelligence did affect the relationship between environment and concentration but only for single sub-measures of the concentration task. Time pressure did not moderate environmental effects on work behaviour or performance. Since I have examined each moderator only in one study, I cannot draw conclusions about the stability of the effects. However, based on these findings, I conclude that moderators, such as characteristics of the task or the individual, have the potential to affect the relationship between environment and work performance and have to be taken into account to explain the process.

General discussion

Methodological implications and future research

Although I found only small to medium-sized effects in the individual studies which were not stable across all sub-measures, there is an interesting picture subsumed. Findings indicate that typical work environments are associated with working and seem to activate an internal state that facilitates cognitive performance and makes decisions more risky compared to leisure-associated environments. I would like to emphasize that participants performed exactly the same tests and assessments with the only difference being that once a short exploration of a virtual work or leisure environment preceded or that the experiment was conducted within a real work or leisure environment, respectively. This simple difference has affected performance in standardized, objective performance tests indicating that the environmental manipulation must have influenced information processing in some way. However, I cannot conclude for certain whether this is due to the activation of a work-related concept because the internal process was not assessed directly. Additionally, methodological limitations have to be considered and more in-depth research is needed to make generalised statements.

Manipulation of environments.

As already explained, I combined laboratory and field methods to balance the advantages and disadvantages of both approaches. Thus, on the one hand, I had the opportunity to control specific characteristics of the environment in the laboratory, while I had the chance to examine the ecological validity in the field on the other. However, both methods entailed several methodological limitations that have to be discussed.

It is obvious that despite the use of modern technology, virtual environments in the laboratory still have limitations in design and are not true to reality. Virtual environments offer the opportunity to present each participant exactly the same environment with exactly the same environmental parameters, thus, various variables (e.g., temperature, noise, or exposure) can be kept constant. However, this has the disadvantage that the presented stereotypical but yet artificial environment is not the typical work or leisure environment for every single participant and association strength might vary substantially. In the case of the virtual office, associations with work may still be strong enough, as most people associate work with an interior equipped with a desk, a computer, and other work utensils. For the virtual leisure environment, however, this problem might be more severe, as each person associates a different environment with leisure due to individual preferences in terms of designing private retreats. For some, a quiet balcony with little distraction may be relaxing, whereas for others, a living room fitted with the latest consumer electronics represents the typical leisure experience. Thus, the virtual garden might not have activated the same association with leisure, depending on different experiences with locations for vacation or relaxation. Another limitation is the artificial situation of the laboratory. All participants explored the virtual environments in the same laboratory room within a research institute. This sterile room itself resembles rather an office than a leisure environment and could have triggered competing associations regardless of the explored virtual environment.

Furthermore, design specifics of the virtual environment itself could have produced unforeseen effects. For example, the virtual leisure environment (garden and park) contained more natural objects (outdoor area with meadow, trees, and plants) than the virtual office environment (interior with office equipment and only small pot plants). Research has already shown that natural views influence cognitive processing by so-called natural restoration effects (e.g., Berman, Jonides, & Kaplan, 2008; R. Kaplan, 1993; S. Kaplan, 1995; Korpela, Bloom, & Kinnunen, 2014; Largo-Wight, Chen, Dodd, & Weiler, 2011; McCoy & Evans, 2002; Richardson et al., 2016; Tennessen & Cimprich, 1995). Interacting with natural environments has been shown to improve cognitive performance (Berman et al., 2008), to be stress reducing (e.g., Korpela et al., 2014) and to restore attention capacity after it has been depleted (e.g., R. Kaplan, 1993; S. Kaplan, 1995). Therefore, it might be wise for future research to keep natural stimuli constant when comparing work and leisure environments and to refine the design of virtual realities.

In order to keep environments realistic, they must contain a large number of different, mundane objects and stimuli (e.g., natural or artificial materials, furniture, colours, or atmosphere). This multidimensionality of environments and situations complicates to draw clear conclusions about how each of these entities affect cognition separately (Rauthmann, Sherman, & Funder, 2015). Future research has to delineate single factors more clearly and examine them in a smaller scale in the next step. The difficulty of competing influential factors also arises for investigations in the field and real environments are less controllable. Real environments greatly differ in terms of atmosphere, climate conditions, space, or noise, and external disturbances are common, be it an interruption through a colleague or a slow internet connection. In addition, participants' behaviour or motivation to conduct the experiment cannot be monitored and reliable task processing might be problematic. However, field experiments offer a decisive advantage: Participants did not experience the same predetermined, artificial environments but were asked to choose their own typical work or leisure environment. Therefore, individual associations with work or leisure should have been strong enough to activate the intended concepts.

Indirect measures of concept activation.

As already mentioned, it is impossible to directly measure an internal process such as concept activation. However, the behavioural data I have obtained in my studies suggest that environments triggered some kind of process that in turn influenced behaviour. Effects were found with regard to two different work performance criteria; Cognitive performance (i.e., attention and concentration) and decision making. Thus, environmental influences seem to be broad rather than specific, which supports the assumption of effects due to automatic concept activation. A concept simultaneously activates various associations and can also be related to diverse behaviours.

Since concepts are formed individually, an activation of a work or leisure concept due to environment manipulation should be different for each participant. Some participants might have held great associations of the environment with the intended concept and behaviour, whereas associations of others might not have been sufficient to affect behaviour or performance. Additionally, it might be possible that even though concepts were activated at the beginning, they might have weakened or dispersed in the course of the experiments. During the assessments other factors might have caused competing processes, for example distracting thoughts, surrounding objects that were associated with something else, or characteristics of the computer-supported tests. Research also indicates that goals, that might have been activated before the actual start of the experiment, influence subsequent cognition and performance (e.g., Bargh, 2006; Gollwitzer, Sheeran, Trötschel, & Webb, 2011; Shah & Kruglanski, 2002). For example, starting the experiment with the target to try hard might have impeded manipulations.

In order to investigate the straight influence of concept activation on behavioural measures, I intended to activate concepts detached from environments in studies 5a and 5b. By means of a well-established priming task, either a work or a leisure concept should have been activated to investigate potential effects on subsequent work performance. Results of these studies did not reveal any significant performance differences between work or leisure concept groups. This finding indicates that the internal process (assumed concept activation) that has been shown to be triggered by the environment in previous studies (study 1- 4b) cannot be replaced by pure cognitive priming. Thus, something else in the environment might activate this process that is strong enough to affect behaviour. Priming studies 5a and 5b were only a first attempt and there is a great deal of potential for future research. However, using a variety of methods (such as self-reports or free association tasks), I indirectly measured activation of work or leisure concepts. Findings of these approaches suggest that environments, as intended, did indeed either activate associations related to work or to leisure. For example, participants have reported to be in a “work mode” after exploring the virtual office environment or while being in their real office, whereas participants reported to be in a “leisure mode” in leisure environment conditions. Therefore, participants’ subjective perceptions seem to be very well affected by the environment what should in turn also influence behaviour and performance. Future research needs to go into more detail concerning internal processes and continue to attempt to measure concept activation.

Potential moderators and competing effects.

As described earlier, results indicated that a row of moderating factors (e.g., environment-task fit, time pressure, mood, personality traits) play a role in the relationship between environment, and behaviour and performance. It can be assumed that a greater number of factors should be considered as well, for example, age, experience, and habituation, as well as individual work types.

Decision-making behaviour and concentration has been shown to develop and change during the life span (e.g., Deakin, Aitken, Robbins, & Sahakian, 2004; Steinberg, 2007). Mean age of the participant samples in my studies was quite low, therefore the transferability to older age groups has to be investigated in future studies. This goes hand in hand with potential differences due to experience levels. Younger age groups with less work experience (e.g., students or employees at early stages) might be affected differently by external surroundings than employees that have been used to mobile work for decades. After some time, also untypical environments such as the train to work, the favourite café, or the park in the lunch break should lose their untypical character, individuals might get used to it and associate these surroundings with work in the same extent others do with their office. Differences in work performance between environments should decrease and even vanish with sufficient experience. Work behaviour in a typical work environment (e.g., the office) should not only generally differ to an untypical environment, but there should also be a difference between an unknown, untypical environment (e.g., a newly opened café) and a well-known but still untypical environment (e.g., the favourite café). Future research should control environments for familiarity in order to investigate these effects, as well as individual learning experience with mobile work. Although 61% of German employers have introduced some kind of mobile work form in 2016 (Statistisches Bundesamt, 2016), it is still a recent and ongoing development and not yet common-place in everyone's life. As soon as mobile and ubiquitous work forms have firmly established in the centre of society, performance differences might downsize substantially.

Findings already indicated moderating effects of personality traits and it is reasonable to assume that every individual is affected differently by external surroundings. Some people seem to be able to work everywhere, even in a crowded train, whereas others are already distracted by the typing noise of their colleagues or cannot read in the train due to motion sickness. For some people it might be easier to acclimate to mobile work than for others due to different prerequisites, competencies, and individual differences in perception. For example, conscientiousness or action orientation (Hossiep & Paschen, 2003), absorption capacity (e.g., Tellegen & Atkinson, 1974), or impulsivity and sensation seeking with regard to decision making (e.g., Lejuez et al., 2002; Nicholson et al., 2005; Zuckerman & Kuhlman, 2000) are obvious assumptions to name just a few. Future research should further investigate which exact characteristics make up a good ubiquitous worker and how these characteristics might be developed or practiced. Not only from the employees' perspective but also from the employers' point of view: Factors such as organizational climate, employer traits, external restrictions, job satisfaction, organizational commitment, and personal work control have been shown to be influential as well (e.g., Amabile, 1988; Blumberg & Pringle, 1982; Lee & Brand, 2005; Oldham & Cummings, 1996; Pritchard & Karasick, 1973; Shore & Martin, 1989; Tesluk, Farr, & Klein, 1997).

Assessment of dependent variables.

To be able to assess knowledge work performance by means of well-established, standardized tests, I focused on measures of cognitive performance and decision making. Of course, however, knowledge work consists of a lot more characteristics and those two criteria are just representatives of typical knowledge work activities.

For example, untypical environments might be beneficial for creative tasks by promoting innovative ideas. Transferability to other work behaviours remains unclear and future research has to investigate, whether environments have different effects on other knowledge work activities.

Although used assessments have been shown to be reliable and were already administered in previous research, each test still has some downfalls. For example, I assessed concentration as an important prerequisite of actual work performance. However, it is unclear whether concentration in a standardized concentration task can be transferred to concentration in actual work tasks. In addition, all measures of decision making included hypothetical and no real decisions. Thus, valid conclusions about decision-making behaviour with real consequences have to be drawn with caution. The test setting within all studies was quite artificial and might not have resembled an everyday work situation. Future research should concentrate on work tasks with higher ecological validity. In real working life it seems reasonable to assume that mobile workers choose their work activity with regard to their current surrounding and might adapt their work strategy deliberately. Mobile workers might for example postpone making a challenging mathematical calculation when they are in a loud environment and give priority to a less effortful task. Investigating these real life work strategies is very important to be able to draw conclusions about successful mobile and ubiquitous work.

Practical implications and conclusion

Based on my findings, I will answer the introductory question (“does where you work affect how you work?”) with *yes*, I found differences in cognitive performance and decision making with regard to work-related and leisure-related environments. However, the digitalisation of work life is progressing rapidly and mobile work forms such as ubiquitous working will become indispensable in the future. As effect sizes are small to moderate and effects appear unstable for different sub-measures across the studies, I suggest that working in different environments, apart from the traditional office, does not generally impede work performance and findings do not advise against mobile work forms in general. Whether mobile work forms are purposeful or not, is not a single yes-or-no-answer but depends on characteristics of task and individual. Some factors might protect mobile workers from being affected at all, for example high numerical intelligence or balanced to relatively positive mood. In addition, it might be wise to choose work environments with regard to a match with the current work task. For example, when a task needs great concentration and attention, it might be suitable to choose an environment that is more associated with working. When it comes to making decisions, a work related environment might decrease risk aversion, which should be kept in mind for decisions involving far reaching consequences. In addition, mobile workers might get used to untypical environments and performance differences might vanish with enough experience. After a while, a successful mobile worker might be able to deliberately activate a work concept (i.e., setting oneself in a “work mode”), independently from external surroundings.

I used an innovative research approach by combining laboratory methods with field experiments assessing knowledge work performance in a holistic approach. However, as this is a new research field, expanded research is required to investigate the transferability of my results to different environments, various samples, and other work tasks before final conclusions can be drawn, as well as to further develop methods to assess the internal process of concept activation. My dissertation project was a first step into investigating effects of mobile work forms on work performance and gives interesting insights into the relationship between environments, and work behaviour and performance. Making employees and employers aware of these potential effects helps to design ubiquitous work forms in order to guarantee a meaningful application in the digital work age.

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Appendix A - Accepted papers

Have a look around: The effect of physical environments on risk behaviour in work-related vs. non-work related decision-making tasks

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Have a look around: The effect of physical environments on risk behaviour in work-related vs. non-work related decision-making tasks

Due to ubiquitous computing, knowledge workers do not only work in typical work-associated environments (e.g., the office) but also wherever it best suits their schedule or preferences (e.g., the park). In two experiments using laboratory and field methods, we compared decision making in work and non-work environments. We hypothesised that participants make riskier work-related decisions when in work-associated environments and riskier non-work-related decisions in non-work-associated environments. Therefore, if environment (work vs. non-work) and decision-making task (work-related vs. non-work-related) are incongruent, then risk-taking should be lower, as the decision maker might feel the situation is unusual or inappropriate. Although results do not reveal that work-associated environments generally encourage riskier work-related decisions (and likewise for non-work), we found environmental effects on decision making when including mood as a moderator.

Keywords: mobile work; work concepts; environmental effects; decision making; mood

Practitioner summary

Mobile workers are required to make decisions in various environments. We assumed that decisions are more risky when they are made in a fitting environment (e.g., work-related decisions in work environments). Results of two experiments (laboratory and field) only show an environmental effect when mood is included as a moderator.

1. Introduction

Since the nineteen-seventies when modern, mobile forms of working emerged, the classical office with workstations, desktop computers, and office chairs no longer represents the common place work setting. Due to ubiquitous computing and mobile devices, especially knowledge workers are no longer dependent on a certain setting and can conduct their work wherever they are. A great body of research already deals with various forms of mobile and flexible work (Chen & Nath, 2005; Davis, 2002; Drucker, 1999; Koroma, Hyrkkänen, & Vartiainen, 2014; Kurland & Bailey, 1999; Messenger & Gschwind, 2015; Sørensen & Gibson, 2004). Working independently from time and space opens up new possibilities and opportunities but also comes with risks and challenges (Renner, Moskaliuk, & Cress, 2014). Flexible work improves well-being and job satisfaction, offers opportunities for better work-life balance, and increases job autonomy but can also lead to more interruptions and work intensification (e.g., Chesley, 2014; Demerouti, Derks, ten Brummelhuis, & Bakker, 2014; Kelliher & Anderson, 2010; ter Hoeven & van Zoonen, 2015). Flexible workers are able to work wherever it best suits their schedule, personal preferences, or work-related or non-work-related obligations. But what does that freedom of choice mean for productivity and behaviour in typical work activities, such as decision making?

1.1 The environment might act as a prime

Physical features of the environment and the design of offices and work spaces impact different aspects of work behaviour, performance, and well-being (e.g., Ceylan, Dul, & Aytac, 2008; Dul, Ceylan, & Jaspers, 2011; Hill, Ferris, & Märtinson, 2003; McCoy & Evans, 2002; Vischer, 2007). For example, ventilation rates and temperature (Seppänen, Fisk, & Lei, 2005, 2006; Varjo et al., 2015), window views (e.g., Stone & Irvine, 1994), colours (e.g., Stone & English, 1998), or privacy (e.g., Block & Stokes, 1989) have been shown to be influential. Besides these physical aspects, more abstract elements (i.e., primes) have also been found to influence work behaviour and performance. Priming research has examined various kinds of primes that shape behaviour and information processing; for example, adjectives (e.g., Bargh & Williams, 2006), stereotypes (Dijksterhuis & van Knippenberg, 1998; Förster, Friedman, Butterbach, & Sassenberg, 2005), or physical objects (e.g., a briefcase that is associated with business makes behaviour more competitive, Kay, Wheeler, Bargh, & Ross, 2004; using a red pen leads to higher error detection, Rutchick, Slepian, & Ferris, 2010; or the mere presence of a lightbulb enhances performance in an insight task, Slepian, Weisbuch, Rutchick, Newman, & Ambady, 2010).

According to concept theories, these effects might be the result of an automatic activation of concepts. Cognitive schemas (Fiske, 2000) or concepts (e.g., Barsalou, 1982) are mental representations of knowledge about elements and stimuli in the world, including all relevant information, experience, and relations, that guide how new information is processed. When a concept is activated, all relevant knowledge about rules and norms, expectancies, attitudes, corresponding resources, and behavioural responses which were commonly stored with the concept are mutually reactivated.

Concepts and the association between specific cues and the mental representations are learned through prior experience and conditioning and are retrieved from memory (e.g., Barsalou, 2016; Feinberg, 1986; Fiske, 2000; Wheeler & Petty, 2001).

Because cognition always occurs within situations, concepts also include information about situational characteristics (Barsalou, 1999, 2002, 2003; Yeh & Barsalou, 2006). For example, through continuous experiences people associate typical environments with typical artefacts, people, actions, or tasks (situated conceptualization theory, e.g., Barsalou, 2016). Being outside in a nice park sitting on a garden bench (a typical non-work-associated environment) often involves a relaxing activity, such as reading a book, having a chat, or just enjoying the fresh air. In contrast, being in an office sitting at a writing desk (a typical work-associated environment) is commonly accompanied by more demanding activities that need high concentration and effort, such as writing a report, developing ideas, or making calculations or difficult decisions. This entrenched knowledge about relationships between environments and actions supports in turn the selection of adequate behaviour because inferences about which behaviour is adequate within the current situation are produced automatically as soon as the situation arises (e.g., Barsalou, 2016, Yeh & Barsalou, 2006).

Therefore, physical environments can also act as primes and activate related concepts. Being surrounded by a physical environment like that of a typical office might automatically activate the associated concept of 'work', which includes knowledge about expected behaviour, typical activities, and required resources. The activated concept in turn influences cognitive processing and performance.

1.2 Environment-task fit

Research has shown that a fit between the requirements for a task and the resources an environment supplies, has favourable effects on work behaviour (e.g., Elsbach & Pratt, 2007; Gerdenitsch, Korunka, & Hertel, 2017; Wohlers, Hartner-Tiefenthaler, & Hertel, 2017). There is not *one* environment that is generally superior (Elsbach & Pratt, 2007) but instead environments have to fit the demands of the task to be beneficial, because employees need different supplies for different activities (e.g., Gerdenitsch et al., 2017; Wohlers et al., 2017). For examples, environments that offer little distraction enhance performance in complex tasks whereas higher stimulation enhances performance in routine task (e.g., Block & Stokes, 1989; Stone & English, 1998) or collaborative tasks need environments that foster social exchange with colleagues whereas concentrated work requires individual workspace (Wohlerset al., 2017).

However, what happens if the surrounding environment does not fit the task and activated concepts do not match the specific context of the task? If current work activity (e.g., reading a complex report) is performed in an environment that does not fit (e.g., on the comfortable sofa in the living room), behaviour would be expected to be different from behaviour in situations where activities are conducted in surroundings typically suitable for work. These effects would depend on subjective experiences of the environment such as triggered moods.

1.3 Decision making as a typical knowledge work task

Analysing information, generating knowledge, or finding solutions for complex problems are typical work tasks for knowledge workers (Davis, 2002; Drucker, 1999; Jonassen, 2000). As there is no consensus how to measure productivity of knowledge workers (Ramirez & Nembhard, 2004; Reinhardt, Schmidt, Sloep, & Drachsler, 2011) we selected one typical activity of a knowledge worker: making decisions. Decision making is a facet of cognition that requires the processing of information and involves complex operations (Cokely & Kelley, 2009; Dohmen, Falk, Huffman, & Sunde, 2010; McKenzie, 2005; Newell & Bröder, 2008). When making decisions there is generally some kind of risk; however, in some situations people are able to accept greater risks than in other situations and the ability to take risks has been shown to be crucial for organizational success (e.g., Busenitz, 1999; Busenitz & Barney, 1997; Damodaran, 2007; MacCrimmon & Wehrung, 1988; March & Shapira, 1987; Stewart & Roth, 2001).

Decision making and risk behaviour is a broadly investigated research field (Höijer, Lidskog, & Uggla, 2006; Newell & Bröder, 2008) and has been shown to be vulnerable to a variety of influencing factors such as context (e.g., Shepherd & Rudd, 2014) and current emotional states (e.g., Isen & Patrick, 1983).

1.4 Moderating effect of decision making context

Decision-making behaviour is multidimensional and changes with different task characteristics (Brewer & Kramer, 1986; Jackson, Hourany, & Vidmar, 1972; Kogan & Wallach, 1964; Levin, Schneider, & Gaeth, 1998; Newell & Bröder, 2008; Nicholson, Soane, Fenton-O’Creevy, & Willman, 2005; Payne, 1982; Slovic, 1964; Weinstein, 1969; Zuckerman & Kuhlman, 2000). In general, behaviour in task completion is affected by the type (e.g., Stone & English, 1998; Stone & Irvine, 1994; Slepian et al., 2010) and the complexity (Bodenhausen & Lichtenstein, 1987) of the task and by other characteristics such as the context. Research suggests that people are more willing to take risks when decisions are related to a work context (e.g., Moskaliuk, Burmeister, Landkammer, Renner, & Cress, 2017) because the responsibility for an undesired outcome is perceived as more dispersed in work-related decisions than in personal decisions (MacCrimmon & Wehrung, 1988; March & Shapira, 1987). We should take this context-specificity into account when measuring decision making and must also differentiate between decision making which includes risks that are more related to work and decision making which includes risks that are more related to private concerns (non-work).

We hypothesise that decision making when the context of the task fits the surroundings (such as when work-related decisions are made in a typical work-associated environment) is different from decision making in situations in which the task context and the environment do not fit together. Since making decisions also includes taking some risks, we hypothesise that a person would dare more (make more risky decisions) in situations in which they are used to making certain kinds of decisions. Therefore it follows that greater risk would be taken in work-related decision making tasks when the decisions are made in a work-associated environment. The opposite would also be expected, that greater risks in non-work-related decision making tasks would be taken when the decisions are made in a non-work-associated environment. If environment and decision making task do not fit together (e.g., work-related decision making in non-work-associated environments) risk-taking should be lower, as the decision maker might feel the situation is unusual or inappropriate.

1.5 Mood as a moderator

In this experiment, we investigated the effect of the environment on work-related and non-work-related decision making. We assumed that this effect depends also on other circumstances, such as current mood. Ashkanasy, Ayoko, and Jehn (2014) explain that the effects of physical environments on performance and behaviour transpire by means of affective events that are influenced by situational factors (Weiss & Cropanzano, 1996). Specific features and configurations of workplace environments stimulate affective events (i.e. current mood; e.g., Stone, 2001), which in turn influence behaviour.

Mood influences different aspects of information processing and decision making (e.g., Clore, Gasper, & Garvin, 2001; George & Zhou, 2007; Hirt, Levine, McDonald, Melton, & Martin, 1997; Isen & Patrick, 1983; Lerner, Li, Valdesolo, & Kassam, 2015; Martin, Ward, Achee, & Wyer, 1993; Mittal & Ross, 1998;

Raghunathan & Pham, 1999; Yuen & Lee, 2003). Schwarz and Clore (2003) assumed that "[…] thought processes are tuned to meet the processing requirements apparently posed by the situation, resulting in systematically different processing strategies under happy and sad moods". Chartrand, van Baaren, and Bargh (2006) suggest that people perceive their current moods as indications of the valence of their present environment. Experiencing a negative mood might be interpreted as a sign that one's environment is problematic and that particular attention should be paid to the current situation resulting in a more effortful processing strategy. Experiencing a positive mood might signal that the current environment is safe and that a less effortful processing strategy is sufficient (Chartrand et al., 2006). In some cases, people use their current moods and feelings as a basis of judgment and during positive moods, people tend to overestimate the likelihood of positive outcomes and to underestimate the likelihood of negative outcomes whereas the reverse holds true for people in negative moods (Schwarz, 2000, 2001). Because risk aversion depends on how the probability of a positive or negative outcome is perceived, mood is an important influencing factor on decision-making processes (e.g., Dolan, 2002; Isen & Patrick, 1983; Mittal & Ross, 1998; Schwarz, 2000; Yuen & Lee, 2003).

Positive and negative moods affect work behaviour differently (e.g., George & Zhou, 2007; Raghunathan & Pham, 1999). It is difficult to derive general assumptions of mood effects on performance and behaviour (Hirt et al., 1997; Isen & Patrick, 1983). To the best of our knowledge, up to now no research has been conducted that investigates the relationship between moods and perceived environment-task fit. Based on previous findings in mood research, we assume in an explorative approach that decisions made by individuals in negative mood states should be affected differently by the environment and task context than decisions made by individuals in positive mood states. We assume that individuals experiencing negative mood states should be more sensitive to the environment-task fit, as they might need and prefer conditions that 'feel good' (e.g., doing a task in a convenient surrounding) to make more risky decisions. We also made the opposite assumption, that individuals experiencing positive mood states would not be affected by environmental effects on decision making.

1.6 Study overview

To sum up, in this paper we assume that a work-associated vs. a non-work-associated environment has the potential to activate an associated work vs. non-work concept which in turn should affect work-related and non-work-related decision making. We further assume that participants dare more and therefore make more risky decisions in an environment that fits the context of the decision (e.g., work-related decision making in a work-associated environment vs. non-work-related decision making in a non-work-associated environment, respectively).

Hypothesis 1a: Participants make more risky decisions in a *work-associated environment* (compared to a non-work-associated environment) when the decision making task is *work-related.*

Hypothesis 1b: Participants make less risky decisions in a *work-associated environment* (compared to non-work-associated environment) when the decision making task is *non-work-related*.

We further investigate in an exploratory manner if the effect of the environment on decision making is moderated by *mood*.

We address these research issues in two studies: In a controlled lab experiment using virtual environments to prime (therefore to activate) concepts of work vs. non-work (*Experiment 1*) and in an ecologically valid field experiment using real-life environments to prime concepts of work vs. non-work (*Experiment 2*).

2. General method

2.1 Design and procedure

We conducted two experiments in 2x2 designs, with two environment conditions: *work-associated environment* vs. a *non-work-associated environment* (varied between subjects) and two task conditions: *work-related* vs. *non-work-related decision making* (within subjects). We did not manipulate task condition experimentally but assessed decision making in *work-related* vs. *non-work-related* decision contexts[1]. Design, measures, and assessment of the dependent variable and moderators were identical for both studies. Tasks and instructions were written in German. All of the data were recorded anonymously and participants signed informed consent statements. After completing the study, participants were fully debriefed and generated a personal code in order to be able to withdraw any data. Both experiments were conducted in compliance with the ethical standards of the American Psychological Association.

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[1] In addition to decision making tasks, two concentration tasks were included (Psychomeda Konzentrationstest, KONT-P, Satow, 2011; Zahlen-Symbol-Test, ZST, Tewes & Wechsler, 1991), as Experiments 1 and 2 were part of a larger research project. We do not report results at this point because they are extraneous to this study.

2.2 Assessment of work-related vs. non-work-related decision making

We measured decision making by means of 13 items which involved hypothetical situation dilemmas (SD). Items were construed following the 12 item choice dilemma questionnaire (CDQ) by Kogan and Wallach (1964). We excluded three items because they were culturally inadequate or no longer currently valid, but we added four items derived from Jackson et al. (1972) which measure monetary risk, physical risk, ethical risk, and social risk. We used items from the inventory of both questionnaires in order to cover a broad range of risk situations and life domains (i.e. investments, health, career, family).

In a pretest with $n = 24$ participants (20 female, age 22 – 56, $M = 27.79$, $SD = 7.77$), all 13 items were rated as to whether they describe a work-related vs. a non-work-related decision making task on a scale from 1 (work-related) to 6 (non-work-related). A mean score was calculated for each item. With a cutoff of 3.5, an item with a mean of ≤ 3.5 was scored as 'work-related decision making' and an item with a mean of > 3.5 was scored as 'non-work-related decision making'. Ratings resulted in a quite evenly distribution of items. Seven items (N°1, N°3, N°7, N°10, N°11, N°12, N°13) were rated as being representative of work-related decision making, for example, 'Imagine you are developing an innovative, promising business idea but you would have to quit your permanent position in order to realize it. However, it is uncertain if the idea will turn out to be profitable. Would you dare to quit your permanent position?'. Six items (N°2, N°4, N°5, N°6, N°8, N°9) were rated as being representative of non-work-related decision making, for example, 'Imagine you are at the airport waiting for the flight that takes you to your well-deserved vacation destiny but you are experiencing strong stomach pain. You could either ignore the pain hoping it will disappear by itself or miss the flight and go to see a doctor at the hospital. Would you dare to take the flight?'. Consequently, we calculated two different decision making scores by averaging the relevant items, resulting in a *work-related decision making score* and a *non-work-related decision making score*. The work-related decision making score ($M = 3.11$, $SD = .96$) and the non-work-related decision making score ($M = 5.39$, $SD = .42$) differed significantly, $t(23) = -10.34$, $p < .001$.

In the main study, participants were asked to decide for each of 13 hypothetical scenarios whether to engage in risky or non-risky behaviour. For each situational dilemma participants had to choose between six more or less risky options. Choosing the option that totally excluded any risk was weighted with a score of 1, choosing the most risky option was weighted with a score of 6 (also scores of 2,3,4,5, were assigned respectively). As described above, items were averaged as a *work-related decision making score* and a *non-work-related decision making score*.

2.3 Mood as a Moderator

Mood was assessed by means of the Aktuelle Stimmungs Skala (ASTS - English: Current Mood Scale, Dalbert, 1992). The ASTS consists of 16 adjectives describing mood according to four categories (sadness, hopelessness, fatigue, and positive mood). Participants rated how those adjectives fit their current mood on a 7-point Likert-scale. Ratings of relevant adjectives were summed across 4 mood scales; higher values indicated a stronger expression of the mood category. The ASTS offers sufficient internal reliability with a Cronbach's Alpha between $\alpha = .83$ and $\alpha = .94$ (Dalbert, 1992).Sadness, hopelessness, and fatigue were positively correlated (r = .46 – 74 in the laboratory; r = .34 – 78 in the field; Pearson correlation coefficient). Positive mood was negatively correlated with sadness, hopelessness, and fatigue (r = -.47 - -.36 in the laboratory; r = -.61 - -.41).

2.4 Activation of concepts

We included a free association task as a manipulation check at the end of the studies in order to check whether work-associated vs. non-work-associated environments were able to activate associated (work vs. non-work) concepts. Participants were asked to write down as many words or phrases that sprang to mind within one minute. Three independent blind raters rated the words in three categories and gave one of three scores: a 1 if the word or phrase was related to work, a -1 if the word or phrase was related to non-work or leisure, 0 if the word or phrase was neither related to leisure or non-work or if it was related to both equally. Inter-rater reliability was acceptable with a mean average measure ICC = .88 in the laboratory and ICC = .89 in the field experiment (two-way random intraclass correlation, absolute agreement, cf. Shrout & Fleiss, 1979).

2.5 Environment variables and demographic data

We assessed several variables in order to check if manipulations of the environment were successful (further described in the method section of each experiment). In both experiments, we asked participants to rate their agreement with following statements on a 5-point Likert-scale: ‘I associate the current surroundings with work’ and ‘I associate the current surroundings with leisure’. Higher values indicate higher association. Demographic data of interest were gender, age, level of education, current state of employment (employed: yes or no), and professional status (two questions “I’m in a leading position” and “I have decision-making power”; rating from 1 to 5). In addition, we assessed individual experience with ubiquitous working (whether participants could decide where they work, when they work, and how often they work remotely. We also asked if they perceived that their work outcome benefitted from mobile working opportunities).

2.6 Analyses

We investigated differences between two groups by means of t-tests for independent samples. Univariate variance analyses were used to assess interaction effects. *Environment* was treated as a two-stage factor (*work-associated* vs. a *non-work-associated*). We did not manipulate task condition experimentally but assessed decision making in *work-related* vs. *non-work-related* decision contexts. Therefore we did not include it as a factor in the analyses but calculated separate models. We followed recommendations by Hayes (2012) in conducting moderation analyses with the help of PROCESS Modelling.

3. Study 1

3.1 Method

Experiment 1 was conducted in the laboratory. We manipulated the environment with the help of virtual 3D-environments, designed by TriCAT GmbH[2]. Such virtual environments provide a complex sensory experience in order to manipulate the environment in a controlled, but still realistic, manner.

3.2 Participants

[2] www.tricat.net

Out of 141 volunteers, 9 participants were excluded from the analyses because in one of the control variables the subjectively perceived environment did not fit the manipulated one. The remaining 132 participants had a mean age of 23.58 (*SD* = 3.61, range from 18 to 35), majority (*n* = 91) was female. Participants were randomly assigned to both environment conditions (*n* = 66 work vs. *n* = 66 non-work). A majority of participants (*n* = 79) indicated that they had at least a part time job, the remaining 53 participants were students. Volunteers were paid 8€ for participation.

3.3 Procedure and manipulation of the environment

After being seated and signing an informed consent statement, participants started the experiment with a 5-minute free exploration through the virtual environment (work vs. non-work) from the first-person perspective. Participants were asked to empathize with their environment, thinking about how they would spend their time if they were there in actuality. Participants navigated through the environment with help of the integrated keyboard and the computer mouse. It was possible to sit down on the virtual furniture by means of a mouse click. Presentation of the virtual environments and all of the tasks and assessments were conducted on a laptop (HP 15.4” HP EliteBook 8530p).

The virtual environment was programmed in Unity R Pro © (Unity R Pro, 2016). It consisted of a flat office building with three rooms, surrounded by a large terrace and a park. The office building and the outside park were connected via a sliding door. In the work-associated environment conditions, participants were only allowed to stay within the office building, navigating through the three office rooms. Office rooms were furnished with a desk, chairs, white boards and flip charts. In the non-work-associated environment condition, participants were only allowed to stay outside, navigating through the terrace and park area. The park area consisted of lawns with benches, a tiled terrace with garden furniture and trees (see Figure 1).

Figure 1. Screenshots of the work (left) and non-work (right) environments.

Measurements and tasks were conducted via an online questionnaire with the help of a virtual tablet while participants were still immersed in the VE. After five minutes the participants were asked to sit down virtually on either a desk chair (work-associated environment) or a park bench (non-work-associated environment) and to open a virtual tablet by clicking on it. The questionnaire was presented on the virtual display of the tablet within the virtual environment. This meant that while participants filled out the survey on the tablet, they still had the possibility to raise their vision seeing the virtual environment surrounding them.

After opening the tablet, the experiment followed the general procedure of assessing decision making[3], the moderators and the control variables. In Experiment 1, one control variable was added to the general procedure: a questionnaire assessing immersion and any dizziness or nausea experienced in the virtual environment (Presence questionnaire by Witmer & Singer, 1998).

3.3 Results and discussion

Manipulation of environments

Regarding the closed question asking for associations of the environment with work vs. non-work, the manipulation worked out as expected. Participants in the work-associated environment did associate the environment more with work (M = 4.55, SD = 1.46) compared to participants in the non-work-associated environment (M = 1.92, SD = .95), $t(130) = 12.232$, $p < .001$. And the other way round, participants in the non-work environment associated the environment more with leisure (M = 4.52, SD = 1.62) compared to participants in the work environment (M = 1.79, SD = .69), $t(130) = -12.58$, $p <.001$. This also held true for the additional measurement at the end of the experiment (both $p <. 001$ in the expected direction). In addition, the free association task indicated successful manipulation. One participant is missing in the analyses as he/she did not insert a free association. Participants in the work-associated environment mentioned more work-related words (M = -.10, SD = .18) than participants in the non-work-associated environment (M = .14, SD = .19), $t(129) = 7.40$, $p < .001$.

Effects of the environment on work-related vs. non-work-related decision making

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[3] In addition KONT-P and ZST were assessed in a randomized manner, see section 2.1.

First of all, we examined if there were any effects of the environment on work-related or non-work-related decision making, without considering mood.

In *Hypothesis 1a* we assumed that participants would make more risky decisions in a work-associated environment (compared to a non-work-associated environment) when the decision making was work-related. We did not find any differences in *work-related decision making*: the decision making of participants in the work-associated environment (M = 3.21, SD = .55) was not riskier than the decision making of participants in the non-work-associated environment (M = 3.12, SD = .73), $t(130)$ = .82, p = .413. Regarding *Hypothesis 1b*, we also didn't find any differences in *non-work-related decision making:* the decision making of participants in the work-associated environment (M = 3.13, SD = .57) was not any less risky than the decision making of participants in the non-work-associated environment (M = 3.21, SD = .72), $t(130)$ = -.70, p = .488.

Conditional effects of the environment

We next examined the conditional effects of the environments on work-related vs. non-work-related decision making, this time including *mood* in a moderation model (Model 1 as suggested by Hayes, 2012). Conditional effects (b_{CE}) of the environment on decision making are only reported when the bootstrap confidence interval (bootstrap = 1000) of the interaction does not include zero.

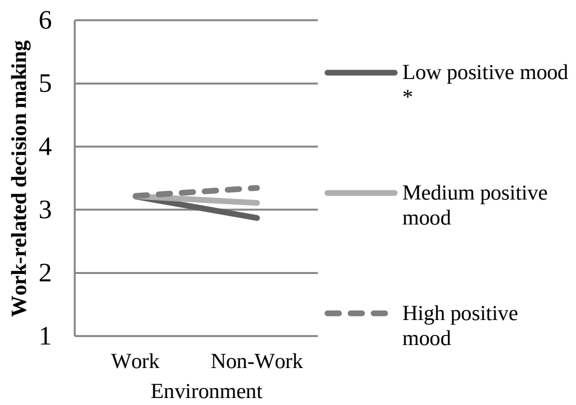
Non-work-related decision making in *work-associated* environments was not affected by a positive mood. However, we did find a conditional effect of environment on *work-related decision making* for a low (one standard deviation below the mean) positive mood: Participants experiencing a low positive mood showed more risky behaviour in work-related decision making when they were in a work-associated environment (see Table 1, Figure 2) compared to the non-work-associated environment. Note: the effect of a positive mood has to be treated with caution, as the confidence interval of the coefficient includes zero (see Table 1).

Table 1. Conditional effect of environment on work-related decision making.

Model summary	*R*	R^2	MSE	*F*	Df1	Df2	*p*
	.25	.06	.41	2.89	3	128	.038
		b	se	*t*	*p*	CI_l	CI_h
Constant		3.19	.35	9.00	.000	2.49	3.90
Environment		-1.21	.54	-2.23	.028	-2.28	-.14
Positive mood		.00	.02	.06	.952	-.030	.04
Interaction		.06	.03	2.08	.040	.003	.11

Note. Sample size *n* = 132; *R* = coefficient of correlation, R^2 = coefficient of determination, MSE = mean squared error, *F* = F-Test statistics, Df = degrees of freedom, *p* = significance value, *b* = unstandardized beta coefficient, se = standard error, *t* = t-test statistic, CI_l = lower confidence interval, CI_h = higher confidence interval

Figure 2. Conditional effects of the environment on *work-related decision making* (from 1, no risk taking, to 6, high risk taking); separated for work-associated and non-work-associated environment. Lines show low (black), medium (grey), and high (dashed) positive mood (a). Lines marked with an asterisk * show significant effects.



We did not find any significant conditional effect of environment on *non-work-related decision making* when mood was included in the model (all *p* > .143).

Control variables

We did not find any differences between the work and the non-work condition regarding gender, age, level of education, and current state of employment (all *p* > .112). Regarding participants who reported being currently employed, there was one difference in professional status. Participants assigned to the work condition rated the statement “I’m in a leading position” higher (*M* = 1.13, *SD* =.40) compared to participants assigned to the non-work condition (*M* = 1.59, *SD* = 1.07), *p* = .012. However, means in both groups were quite low (note: with a range of 1 to 5) thus this result is negligible. We found no difference for ‘I have decision-making power’ (*p* = .535).

4. Experiment 2

4.1 Method

Experiment 2 was designed as a quasi-experimental field study using an online survey. We did not manipulate the environment but instead asked participants to do the study tasks either in a typical work-associated or a typical non-work-associated environment. We conducted a row of manipulation checks and gathered the effects of several additional control variables in order to be able to control for as many confounding variables as possible.

4.2 Participants

In sum, 126 participants volunteered to fill in the online survey. Four participants were excluded from the analyses because they failed the manipulation checks (subjectively perceived environment did not fit the manipulated one). The remaining 122 participants had a mean age of 26.20 (*SD* = 6.78, range from 18 to 53), the majority (*n* = 79) were female. Participants were randomly assigned either to the work environment (*n* = 60) or to the non-work environment *(n* = 62) condition. Around two-thirds of participants had at least a part time job (*n* = 86), the others were students. The chance to win one of two 25€ vouchers was offered as an incentive.

4.3 Procedure and manipulation of the environment

First contact with participants happened through a short invitation to take part in the study. Those who volunteered were asked to register with their e-Mail address and were afterwards personally contacted with a standardized e-Mail. In the e-Mail participants received the link that led to the online survey and either received (randomly assigned) the instructions to open the survey link in a typical work-associated environment (e.g., work or home office) or in an environment that is typically not associated with work (e.g., in their garden, living room, ...). As soon as the participants were in the assigned environment they were allowed to click on the link. At the beginning of the survey, participants were asked to confirm that they were either in a work-associated or a non-work-associated environment (depending on their instructions), and a manipulation check as described in the general method followed (rate associations of the environment with either work or leisure). The actual assessment started with five open questions that on the one hand were used as a manipulation check and on the other hand had the goal of assisting participants to fully immerse in their current environment, engaging consciously in the perception of their surroundings (1. Where are you? 2. What do you see 3. How is the atmosphere? 4. What did you do in the last half hour? 5. Do you have any other comments regarding your surroundings?). Next, the assessment of work-related and non-work-related decision making[3] followed. The study ended with the assessment of control variables and demographic data (as described in the general method). Participants had to indicate whether they had filled out the survey with a PC/laptop, tablet, or smartphone. After finishing the survey, participants had the chance to submit their e-mail address in order to take part in the voucher lottery.

4.4 Results and discussion

Manipulation of environments

Regarding the closed question asking for associations of the environment with work vs. non-work, the manipulation worked out as expected. Participants in the work environment generally associated the environment more with work (M = 5.07, SD = 1.69) compared to participants in the non-work environment (M = 2.40, SD = 1.02), $t(120) = -10.61$, $p < .001$. And the other way round, participants in the non-work environment associated the environment more with leisure (M = 4.95, SD = 1.68) compared to participants in the work environment (M = 1.93, SD = 1.10), $t(120) = 11.67$, $p < .001$. This also held true for the additional measurement at the end of the experiment (both $p < .001$ in the expected direction).

The free association task also indicated successful manipulation. Three participants are missing in the analyses as they did not insert a free association. Participants in the work-associated environment mentioned more work-related words (M = -.07, SD = .18) than participants in the non-work-associated environment (M = .19, SD =.21), $t(117) = -7.01$, $p < .001$.

Effects of the environment on work-related vs. non-work-related decision making

First of all, we examined if there were any effects of the environment on work-related or non-work-related decision making, without considering mood. *Hypothesis 1a* was not confirmed, as *work-related decision making* did not differ between participants in the work-associated environment (M = 3.18, SD = .81) and participants in a non-work-associated environment (M = 3.12, SD = .62), t(120) = .45, p = .654. In addition, *Hypothesis 1b* was not confirmed, as non-work-related decision making only differed marginally between participants in the work-associated environment (M = 3.09, SD = .72) and participants in the non-work-associated environment (M = 3.33, SD = .69), t(120) = -1.87, p = .064.

Conditional effects of the environment

We did not find any significant conditional effect of environment on *work-related decision making* when we included mood into the model (all p > .441). However, the following three moods did influence the environmental effect on *non-work-related decision making*: a) high (one standard deviation above the mean) sad mood, b) high desperate mood, and c) low positive mood. The sad, desperate, and less positively tuned participants made more risky decisions in a *non-work-associated* environment than in a *work-associated* environment (see Figure 3). Note: the effect of the environment has to be treated with caution, as the confidence interval of the environment includes zero (see Table 2).

Table 2. Conditional effect of environment on non-work-related decision making.

a. Sad mood

Model summary	R	R^2	MSE	F	Df1	Df2	p
	.30	.09	.47	3.94	3	118	.010

	b	se	t	p	CI_l	CI_h
Constant	3.55	.20	17.34	.000	3.15	3.96
Environment	-.46	.28	-1.63	.105	-1.02	.09
Sad mood	-.07	.03	-2.49	.014	-.13	-.01
Interaction	.11	.04	2.74	.007	.03	.19

b. Desperate mood

Model summary	R	R^2	MSE	F	Df1	Df2	p
	.29	.09	.48	3.74	3	118	.013

	b	se	*t*	*p*	CI_l	CI_h
Constant	3.54	.20	17.51	.000	3.14	3.94
Environment	-.42	.28	-1.50	.137	-.98	.14
Desperate mood	-.08	.03	-2.47	.015	-.15	-.02
Interaction	.12	.05	2.60	.010	.03	.21

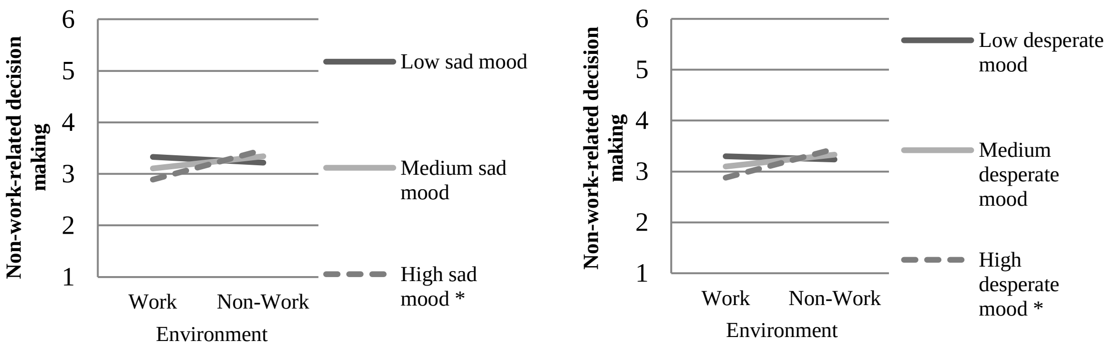
c. Positive mood

Model summary	*R*	R^2	MSE	*F*	Df1	Df2	*p*
	.26	.07	.48	2.97	3	118	.035

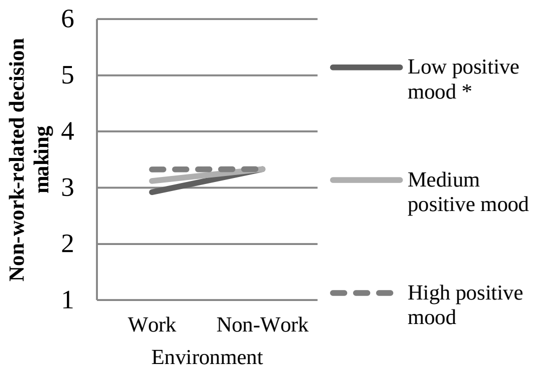
	b	se	*t*	*p*	CI_l	CI_h
Constant	2.41	.31	7.83	.000	1.80	3.02
Environment	.92	.46	1.99	.049	.005	1.83
Positive mood	.04	.02	2.30	.023	.01	.07
Interaction	-.04	.02	-1.60	.112	-.09	.01

Note. Sample size: *n* = 122; *R* = coefficient of correlation, R^2 = coefficient of determination, MSE = mean squared error, *F* = F-Test statistics, Df = degrees of freedom, *p* = significance value, *b* = unstandardized beta coefficient, se = standard error, *t* = t-test statistic, CI_l = lower confidence interval, CI_h = higher confidence interval

Figure 3. Conditional effects of the environment on *non-work-related decision making* (from 1, no risk taking, to 6, high risk taking); separated for work-associated and non-work-associated environment. Lines show low (black), medium (grey), and high (dashed) sad moods (a), desperate moods (b), and positive moods (c). Lines marked with an asterisk * show significant effects.



a. b



c.

Control variables

We did not find any differences between the work and the non-work condition for gender, level of education, current state of employment, professional status, or experience with ubiquitous working (all p > .060) but for age between the work (M = 27.65, SD = 6.87) and non-work conditions (M = 24.81, SD = 6.45), t(120) = -2.36, p = .020). However as mean age was quite low in both groups, this difference is not of further interest.

5. Summary and concluding discussion

Since technical progress has enabled knowledge workers to work in practically any environment, it has become important to investigate whether different environments might have an effect on work behaviour.

In Hypothesis 1a we assumed that participants would make more risky decisions in a work-associated environment (compared to a non-work-associated environment) when the risk is work-related. We did not find any evidence to support this hypothesis in Experiment 1 or Experiment 2. Participants did not show any general difference in work-related decision making between work-associated or non-work-associated environments.

In Hypothesis 1b we assumed that participants would make less risky decisions in a work-associated environment (compared to a non-work-associated environment) when the risk is non-work-related. Again, we did not find any evidence to support this hypothesis in Experiment 1 or Experiment 2, as non-work-related decision making did not differ between environments. However, in Experiment 2, participants in the work-associated environment did show marginally (p = .064) less risky non-work-related decision making than participants in the non-work-associated environment.

In sum, we did not find general differences in a way that typical work-associated environments (e.g., the main office or a working niche at home) encourage more risky work-related decisions compared to non-work-associated environments (e.g., a park or a lounge area), or the other way round. However, we did find several more complex effects of the environment on work-related or non-work-related decision making when including mood as a moderator. This indicates that the environmental effect on decision making is not a blanket effect but depends on characteristics of the person.

5.1 Moderating effects of mood

We did find several moderating effects of mood on decision making in the lab (Experiment 1) as well as in the field (Experiment 2). The manifestation of a certain mood state was shown to have an impact on whether decision making was affected by the environment or not.

Regarding work-related decision making, differences turned out as expected (Hypothesis 1a): participants scoring low on positive mood made more risky decisions in a work-associated environment compared to a non-work-associated environment.

Regarding non-work-related decision making, participants experiencing either a high sad mood, high desperate mood, or low positive mood showed the expected behaviour as well (Hypothesis 1b): participants made more risky decisions in a non-work-associated environment compared to a work-associated environment.

In sum, only negative mood states seem to have made the environment's influence possible. Only participants experiencing high sad, high desperate or low positive moods were vulnerable to an environmental effect on decision making. Our results suggest that balanced or relatively positive moods block out effects of the environment on decision making in the first place. Mood adjustment theories potentially explain this effect. Participants experiencing an unbalanced or relatively negative mood tend to adjust their mood states by means of different behavioural but also cognitive processes (e.g., Knobloch, 2003; Reinecke & Trepte, 2008). It seems reasonable to assume that these processes use cognitive resources (e.g., Bonanno, Papa, Lalande, Westphal, & Coifman, 2004). These cognitive resources might in turn be depleted when attempting to block out influences of the surrounding environment on current activities.

As mentioned in the introduction, effects of mood on performance are asymmetrical with different processes elicited by negative and positive mood states (e.g., Chartrand et al., 2006; George & Zhou, 2007: Schwarz, 2000, 2001; Yuen & Lee, 2003); therefore, this result is not surprising. In line with our findings, negative moods seem generally more influential (e.g., Yuen & Lee, 2003); for example, lightning conditions in the environment did affect cognitive performance but only in negative mood conditions (Knez, 1995; Knez & Kers, 2000). Schwarz and Clore (2003) explain that negative moods have a stronger effect because people usually have positive feelings, which negative moods diverge from and therefore negative moods elicit the perception that something is wrong and that the situation requires explanation and further actions: “being in a bad mood signals a problematic situation, whereas being in a good mood signals a benign situation” (Schwarz, 2001). Further research is needed to investigate this process and effects of mood might be additionally intertwined with other factors. For example, mood effects on decision making are influenced by the framing of decision options (e.g., Isen & Patrick, 1983; Mittal & Ross, 1998; Raghunathan & Pham, 1999) and the mediating role of mood on environmental effects on performance is affected by gender (e.g., Knez, 1995). “

5.2 Limitations and implications

Environment manipulation

When including mood as a moderator, we found effects on work-related decision making in Experiment 1, which was conducted in the laboratory, and on non-work-related decision making in Experiment 2, which was conducted in the field. However, this might be due to different levels of salience of the environments. Although surroundings were manipulated by means of virtual environments in Experiment 1, participants in the laboratory might have had a competing feeling of being in a work environment in both conditions. Laboratories are located within the institute and are furnished in an office-like manner. This might have made the work-associated environments more salient not only for participants exploring the virtual office but also for participants exploring the virtual garden. Therefore, in general, the activation of a *work* concept might have been stronger than a *non-work* concept. However, in Experiment 2 which was conducted in the field in real, ordinary environments, the same might have occurred for *non-work related* concepts: as participants were asked to conduct the experiment in their typical non-work-associated environment, these familiar surroundings might have facilitated the activation of a *non-work* concept. In direct comparison, the linkage between *non-work-associated* environments and *non-work* concepts might have been stronger than the linkage between *work-associated* environments and *work* concepts, because normally people spend a lot more of their lifetime in non-work environments (e.g., the living room or a garden) than within work-environments (e.g., the office). However, at the point of these first results we cannot conclusively explain this effect.

Another point to discuss is that work-associated and also non-work-associated environments consist of a variety of different features and characteristics, such as objects, atmosphere, furniture, light, or temperature, to mention just a few. Up to now it is not clear precisely which features or characteristics are responsible for an environmental effect. This complicates the investigation of environments and situations where actions take place (Rauthmann, Sherman, & Funder, 2015). On the one hand it is important to investigate work behaviour within realistic, individual settings, as it can be assumed that every individual universally associates different environments with the concept of work (e.g., an open plan office at the company premises, a library, or a separate office room at home) or with non-work (e.g., a public park, the balcony at home, or a favourite vacation place). On the other hand, experiments in realistic settings entail the downside of potential confounding variables, as environmental characteristics cannot be controlled in a real setting. Therefore it is also important to investigate work behaviour within controlled, artificial laboratory settings. In our experiments we combined both methods in order to investigate the research question with a holistic approach.

Environment-task-fit

Regarding environmental effects on decision making, the study does have some findings to report. For certain negative mood states, a fit of the environment (e.g., *work*-associated: a typical office) with the task (e.g., making *work*-related decisions) does lead to more risky decisions compared to a mismatch (e.g. making *work*-related decisions in *non-work*-associated environments). One explanation for this finding might be that an environment-task-fit leads to a more secure feeling, which in turn allows participants to dare more. Making work-related decisions in a work-associated environment might feel familiar and appropriate (compared to making private decisions in a work-associated environment or work-related decisions in a private environment). Under these conditions participants might not feel the need to exert a special vigilance. If individuals make decisions framed in a risk context that does not fit their current surroundings, they seem to be more alert, which leads to a more systematic information processing attenuating external influences. Employees should wisely choose their work environments with regard to a fit with their current task (e.g., Kristof-Brown, Zimmerman, & Johnson, 2005; Wohlers et al., 2017).

However, it seems that this effect was not a general one. Whether the environment-task fit comes into effect depended on current mood. The finding that current mood has an impact on whether different environments influence a person's decision making behaviour is of special practical concern. It seems that a negative mood state makes employees vulnerable to external influences. This is an interesting fact, as it is quite easy to make employees aware of their mood and for them to adjust it. Individuals with a relatively balanced or positive mood are not affected by the environment at all. Thus, whenever it comes to working in unusual places, ubiquitous workers should be aware of their mood. With regard to this, Anderson, Kaplan, & Vega (2014) found relieving results: people reported less negative affective states while doing mobile work compared to working in the traditional office.

To the best of our knowledge, our experiments were the first to include mood as a moderator of the relationship between environmental effects, task context and decision making. We found only a few effects and robustness of the findings should be examined by future research. However, our findings are interesting as a first step to explain the process of influences of external stimuli on behaviour such as decision making.

Individual characteristics

Besides mood, there might be other individual characteristics that are also of practical concern, such as personality traits (e.g., Zuckerman & Kuhlman, 2000) or age and experience. For example, research has shown that decision-making behaviour changes throughout the life span and findings indicate that younger age groups may make riskier or more emotional decisions compared to older age groups (e.g., Steinberg, 2007; Deakin, Aitken, Robbins, & Sahakian, 2004). As the mean age of our participant samples was quite low and samples included students and part time workers whose experiences with work life and especially with work-related decisions remain unclear, future research should investigate the transferability of our findings to older and more experienced workers.

Measuring decision making

In this experiment we rated a standardized situation dilemma decision making task in terms of whether risks are related to work or non-work. It has to be noted that standard deviations of risk ratings were quite high, which indicates that it was not that easy for raters to categorize risks clearly. This might also reflect real-life decisions: in real life, most risks are not clearly work- or non-work related but often also blurred. For example, the risk of losing a job is not only work-related, as unemployment would also affect one's private life. Therefore future research should continue to look at other tasks whose contexts (work- vs. non-work-related) are more clearly distinguishable. In addition, decisions were hypothetical and the transferability to real decisions with real consequences has to be further examined. Research has shown that, in some cases, hypothetical decision-making behaviour differs from real decision making (e.g., FeldmanHall et al., 2012; Isen & Patrick, 1983; Vohs et al., 2008), especially in the context of large payoffs (e.g., Kühberger, Schulte-Mecklenbeck, & Perner, 2002). A situation dilemma task that deals with decisions related to the personal life entails that outcomes would imply substantial consequences for the decision maker. Kühberger et al. (2002) argue that "decision making is hypothetical in its very core" because all potential outcomes must be anticipated hypothetically when making a decision, irrespective of whether the decision is real or hypothetical. Because decision making is one of the most common tasks in a work life, it was a plausible starting point but more research is needed to draw a reliable conclusion about real work behaviour.

The conclusion of our experiment speaks clearly in favour of modern work arrangements such as ubiquitous working, at least suggesting that there was not a significant effect of the environments in our study. In general we have shown that it is not impossible to show comparable decision-making behaviour in different environments, not only in a typical work office but also in a park or garden outside. However, employers and employees should keep the possibility of restrictions in mind, as there are several cases when decision making would indeed be affected by surroundings.

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Ubiquitous Working: Do Work Versus Non-work Environments Affect Decision-Making and Concentration?

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New communication technologies and mobile devices have enabled knowledge workers to work independently of location and in more than one fixed environment (ubiquitous working). Previous research shows that physical environments can influence cognition and work performance. We manipulated environment (i.e., a virtual office as a typical *work environment* compared to a virtual garden as a *non-work environment*) and time pressure (i.e., inducing *time pressure* vs. *no time pressure*) in order to investigate whether the environment influences decision-making and concentration. $N = 109$ students participated in this laboratory experiment. We posited (a) that a work environment would activate a work-related schema which in turn would enhance concentration performance and make decisions more risky compared to non-work environments and (b) that the environmental effect is more pronounced if time pressure is present compared to conditions where no time pressure is present. We found modest hypothesis-confirming main effects of environment on decision-making and concentration but no interaction effect with time pressure. As we used an innovative methodology that entails several limitations, future research is needed to give insights into the process and to investigate whether results hold true for all types of work settings, work demands, or work activities.

Keywords: mobile work, ubiquitous working, environmental effects, decision-making, concentration, work demands, personality

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INTRODUCTION

Due to the proliferation of handy electronic mobile devices, such as notebooks, tablets, or smartphones, people can now access data and information easily wherever they are. Mobile device systems are flexible, affordable, and easy to use (Helal et al., 2001) and they allow the economic use of mobile workspaces. New communication technologies induce new ways of working, known by different names: mobile, multi-locational, remote, flexible, distributed, or virtual work (e.g., Lönnblad and Vartiainen, 2012). Each enable employees to work in more than one fixed location. Previous research shows that it does "matter where you work" (Hill et al., 2003, p. 220; Moskaliuk et al., 2017) in the sense that the physical environment can influence cognition and work performance (e.g., Kay et al., 2004; Shalley et al., 2004; Slepian et al., 2010; Steidle and Werth, 2013; Lee et al., 2015). The design features of a workspace (e.g., lightning, furniture, acoustics, or temperature) affects well-being, work satisfaction and also work performance (e.g., Vischer, 2007, 2008). We present a laboratory experiment and discuss how the continuous change of working environments affects work behavior and performance, in terms of decision-making and concentration, depending on characteristics of the work task (e.g., whether time pressure is present or not).

For knowledge workers, one precondition for working successfully, even in multiple, different, and often non-work-related environments, is the possibility to interconnect and combine each environment, for example via some kind of cyberspace (e.g., Halford, 2005) or virtual workspace (e.g., Vartiainen and Hyrkkänen, 2010). Vartiainen and Hyrkkänen (2010) go even further and propose the idea that a mobile multi-locational worker has to work within four distinct spaces, each entailing its own resources and challenges: the physical workspace itself (e.g., home or the main workplace, trains, or cafés), virtual spaces (e.g., internet and intranet, communication tools, or knowledge platforms), social spaces (e.g., social interactions, social networks with customers, colleagues, or family members), and mental spaces (e.g., individual or shared cognitive constructs, thoughts, beliefs, or ideas). Each of these spaces influences the perception of and the behavior within the other spaces (Vartiainen and Hyrkkänen, 2010). Following these suggestions, ubiquitous, mobile workers are not only present in one physical workspace (e.g., in the main office or with a laptop in the park), but also within a combination of the other spaces. This would mean that although a worker is physically working in his living room at home (physical workspace), in his/her thoughts and current mental state s/he might be in his/her main office at the company premises (mental space). Is a successful ubiquitous worker indeed able to activate an appropriate work-related 'mental space' independently of his or her physical environment?

To investigate this question, theories of general cognitive processes should be considered. For example Wilson (2002) summarized several views regarding the assumption that each cognitive process occurs through an interaction with the environment. Cognition is distributed between the individual and the situation and, during a cognitive process, the information perceived within the environment affects that process. In some cases, cognition might also take place without any direct interaction with the environment (e.g., day dreaming or remembering) and these situations can be constructed with help of mental representations. In addition, schema frameworks state that the mind and knowledge of humans is organized and structured by networks of information that are activated when certain things are experienced (e.g., Mandler, 1984). Certain environments activate associated schemas, which may be characterized by knowledge, beliefs and attitudes regarding the environment, or by behavior scripts on how to act within this environment. We posit that a work-related environment activates a work-related schema which leads to an appropriate work-related mental state (e.g., being concentrated and attentive) and to appropriate work-related behavior, thus enabling high performance in work-related activities. An environment not related to work might not activate a work-related schema and therefore may lead to lower performance.

In addition Wilson (2002) states that when cognition involves time pressure, suitable processing strategies are available to guarantee fast information processing. Under pressure, there might not be enough time to generate a detailed mental model of the current environment or situation and it might be more useful to rely on representations of situations acquired through prior experiences. A large body of existing research demonstrates that time pressure affects information processing and decision-making (Kelly and Karau, 1999; Maule et al., 2000; Suri and Monroe, 2003). Incorporating these effects into our previously described assumptions, we rely on several suggestions of the heuristic-systematic model (HSM, e.g., Chaiken, 1980, 1987). The HSM was originally developed to explain information processing in persuasion but can be applied to different areas (Chaiken et al., 1989). Systematic processing is synonymous with an analytic, demanding processing style in which all relevant information and data are comprehensively processed and integrated. Therefore, several situational variables must fit: people must be motivated and sufficient resources and capacities are needed. Time can be included among these capacities and resources. If time is limited and persons experience time pressure, systematic processing becomes less likely and individuals tend to rely on heuristics in order to go easy on resources. Heuristic processing demands less cognitive effort because people focus only on limited information to formulate judgments or decisions. This limited information might include heuristics that may be activated intentionally or automatically. Heuristics are cues that might be learned through prior experiences, for example stereotypes, explicit beliefs, rules, but also schemata. Chaiken et al. (1989) propose that heuristic cues have maximal impact when motivation is low or the capacity for systematic processing is limited, for example when time is constrained. As mentioned above, we posit that environments elicit related schemas and therefore create the potential to act in terms of heuristic cues. Accordingly, the impact of such cues (e.g., activated work- vs. non-work-related schemas) on information processing should be higher when individuals experience time pressure because resources to process systematically are limited. Previous research underpins this assumption (e.g., De Dreu, 2003). Such notions help establish a suitable theoretical framework for investigating possible environmental effects on work behavior and performance (e.g., decision-making and concentration) that might emerge from ubiquitous working.

We measured work behavior and work performance of knowledge workers in terms of a *decision-making* task and a *concentration* task. The abilities to work in a highly-concentrated fashion and take risks are essential aspects of professional routines that are crucial for organizational success of occupations involving knowledge work (Ramirez and Nembhard, 2004; Reinhardt et al., 2011; e.g., managers and entrepreneurs: March and Shapira, 1987; MacCrimmon and Wehrung, 1988; Busenitz and Barney, 1997; Busenitz, 1999; Stewart and Roth, 2001; Rauch et al., 2009). There is no consensus regarding how to measure performance of knowledge workers (Ramirez and Nembhard, 2004). Therefore, we chose to investigate work behavior and work performance through two tasks that include typical activities of knowledge workers and that can be assessed in an objective, standardized way (i.e., making decisions and working with concentration).

In sum, we assume that the environment influences decision-making and concentration. We assume that work environments enhance performance in work-related activities, such as tasks that require a high amount of concentration, and make decisions riskier.

Hypothesis 1a: Decision-making is riskier in the work environment compared to the non-work environment.
Hypothesis 1b: Concentration is higher in the work environment compared to the non-work environment.

Furthermore, we assume that time pressure moderates the effect of the environment on decision-making and concentration. Under time pressure, the impact of the environment through activated work- vs. non-work-related schemata should be more pronounced and should have a stronger effect compared to conditions with no time pressure.

Hypothesis 2a: The enhancing effect of the work environment on decision-making and concentration performance should be more pronounced in conditions with time pressure compared to conditions with no time pressure.

MATERIALS AND METHODS

Design

We conducted an experiment with a 2x2 between-subjects design: two *environment* conditions (work vs. non-work) and two *time pressure* conditions (no time pressure vs. time pressure), balanced for sex. Environment was manipulated with the help of virtual environments presented on a computer screen. The subjective experience of time pressure was manipulated via verbal instructions inducing time pressure or not. We measured *decision-making* and *concentration* as dependent variables with standardized tests.

Participants

A total of 109 students volunteered to participate in the study; eight were excluded from the analysis due to technical problems. The remaining 101 participants were between 18 and 62 years old (M = 23.52, SD = 6.74), 54 were female. Participants were randomly assigned to the four experimental conditions (2 × 2, environment × time pressure). Volunteers were paid 8€ for participation or participated in exchange for course credit, and all data were recorded anonymously. This research complied with the American Psychological Association's ethical principles and received approval from the institute's own ethics committee.

Procedure

After being greeted and seated participants, signed informed-consent statements and were given written instructions. The greeting and verbal instructions differed between the no time pressure and the time pressure conditions (see section "Manipulation of Time Pressure"). Participants in both environment conditions (work vs. non-work) started the experiment with 5-min of free exploration through one of the virtual environments (virtual office or the virtual garden, see section "Manipulation of the Environment"). Participants were instructed to engage with their stay in the environment by trying to imagine themselves there in real life. Afterward, the experimental tasks and assessments began, starting with the decision-making tasks: the Balloon Analogue Reaction Task (BART) was followed by the Holy Laury Lottery (HLL). Subsequently, participants were asked to return to the virtual environment for 3 min, with the same instructions to fully immerse themselves in the environment. The assessment of variables continued with the concentration task [Psychomeda Konzentrationstest (KONT-P)], followed by questionnaires assessing control variables (achievement motivation, subjective feeling of freedom from constraints, the Big Five, ambiguity tolerance, personal need for structure, absorption capacity, and regulatory focus), and an evaluation of the virtual environment. There were also questions regarding time pressure manipulation and demographics (all assessed variables are described in Section "Measures of Work Behavior and Work Performance," the experimental setup is described in Section "Experimental Setup"). The environment projection remained on the wall throughout the whole experiment to maintain the environmental priming (i.e., through displaying the picture section of the virtual environment, where the participant stopped in the prior exploration). All tasks and instructions were written in German.

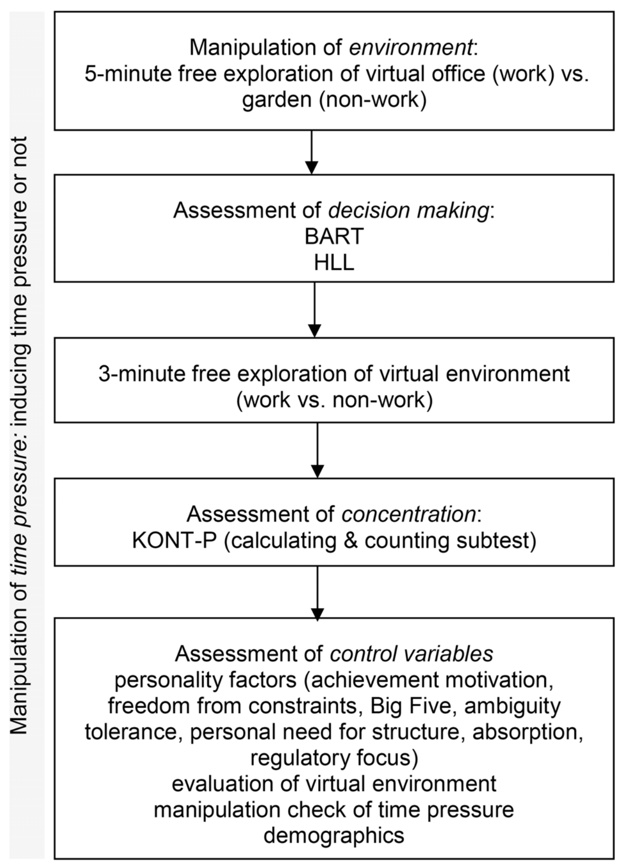

FIGURE 1 | Flow chart of the procedure.

After completing the study, participants were thanked and fully debriefed. **Figure 1** depicts a flowchart of the procedure.

Experimental Setup

All participants completed the experiment with an identical experimental setup. Each participant worked on a desk with two laptop computers (15.4″ screen diagonal). One laptop computer was placed in front of the seated participant (front laptop), while the other laptop was placed slightly to the left on the desk and connected to a video projector and a computer mouse (left laptop). The assessment of the dependent variables as well as data collection was conducted on the front laptop. The participants completed all tasks and questionnaires with the help of the integrated keyboard. The presentation of the virtual environments ran on the left laptop, but the integrated monitor display was set to black and the environments were instead projected large-sized on the wall in front of the desk. Participants navigated through the environment with help of the computer mouse. **Figure 2** illustrates the experimental setup.

Manipulation of the Environment

The environment was manipulated using two virtual environments (see also Moskaliuk et al., 2017). Virtual environment technologies are useful tools for psychological research, as they are able to create sufficiently realistic situations while being able to control for confounding variables (Blascovich et al., 2002) and have already been applied in various research areas (e.g., Cho et al., 2002; Klinger et al., 2005; Slater, 2009; Cohen-Hatton and Honey, 2015). In the work environment condition, participants navigated through a virtual office environment. The virtual office was furnished and equipped like a stereotypical office, for example, with a laptop and office supplies placed on a desk and with an office chair, a bookcase, and a potted plant in the room (see **Figure 3**, right). In the non-work environment condition, participants navigated through virtual Mediterranean garden scenery. The virtual garden included a holiday cottage (not explorable) surrounded by peaceful nature, flowers, trees, a fountain with running water, and lake view (see **Figure 3**, left).

Manipulation of Time Pressure

Time pressure (no time pressure vs. time pressure) was manipulated through of standardized verbal instructions in different parts of the procedure, and with the presence or non-presence of a ticking egg-timer. Participants in the *time pressure* condition were welcomed by the trained experimenter with the following standardized directions: "Unfortunately we have little time for conducting the experiment today, because the room is actually reserved for a different experiment. We will need to hurry up. I will set an egg-timer to check the time that we have." The experimenter started the egg-timer as soon as participants sat down and began reading instructions. Participants could not see the time display of the egg-timer and had no information about when the alarm bell would start ringing (in fact, the alarm bell did not start ringing in any experimental trial). The egg-timer was ticking within earshot of the participant throughout the entire experiment. At the beginning of the second environment exploration, participants were told, "Today, we are doing this in a shorter period of time, because we don't have as much time as usual." After 20 min, the experimenter reminded participants verbally to hurry up. Participants in the *no time pressure* condition received

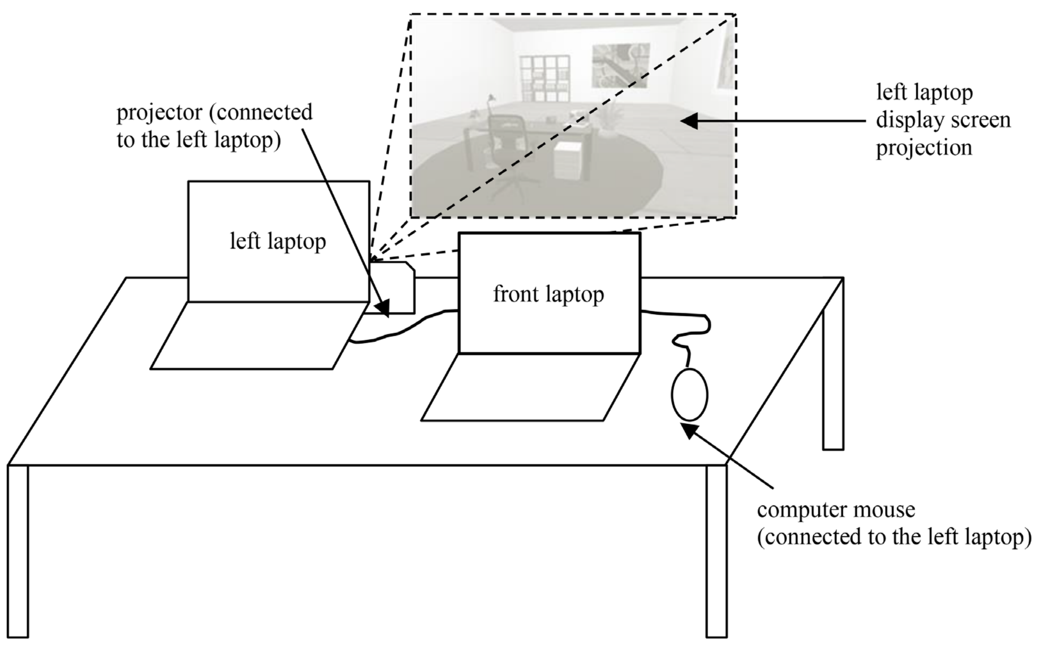

FIGURE 2 | Experimental setup, each participant had his own desk, sitting in front of two laptops. A projector and a computer mouse were connected to the left laptop; the display screen of the left laptop was projected on the wall. A screenshot of the virtual office is displayed.

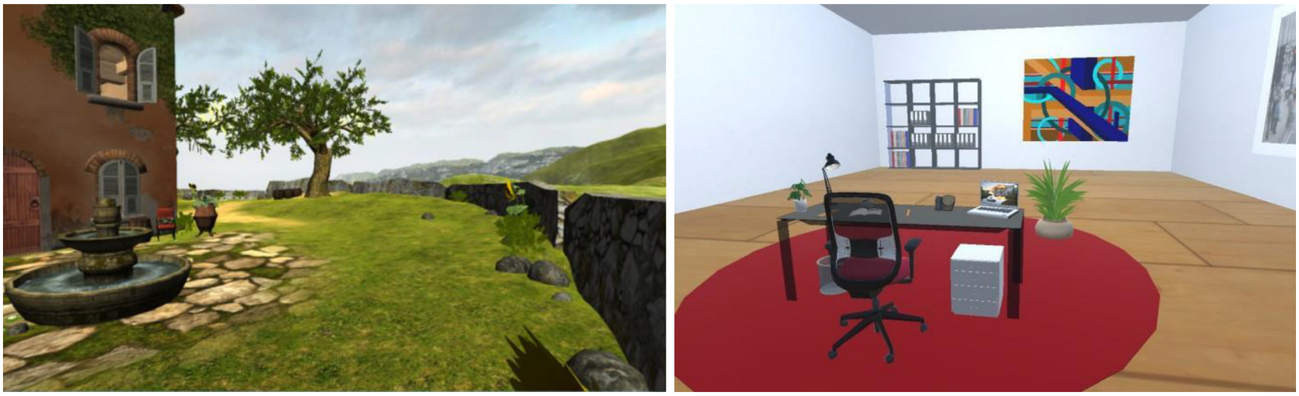

FIGURE 3 | Screenshots of the virtual garden scenery with a holiday cottage, trees, and a fountain **(left)** and of the virtual office with a desk, office chair, and other office supplies **(right)**.

verbal instructions that did not include any time constraints. Participants in the no time pressure condition were greeted with no mention of time at all, no egg-timer was started, and participants were asked if everything was going well instead of being reminded to hurry up after 20 min. In fact, participants in the no time pressure and the time pressure condition had the same amount of time to conduct the experiment. To check the manipulation, we asked "Did you experience any time pressure during the experiment?" A higher rating indicated less subjective time pressure. Participants in the no time pressure condition (M = 5.29, SD = 1.73) experienced significantly less subjective time pressure compared to participants in the time pressure condition (M = 4.13, SD = 1.96), $t(99)$ = 3.12, p = 0.002. Therefore, the manipulation of time pressure (time pressure being present or not) can be considered successful.

Measures of Work Behavior and Work Performance

Decision-Making

We used two measures of decision-making (BART and HLL) since there is still no consensus about whether decision-making is a consistent outcome or whether it depends on the way it is assessed (Kogan and Wallach, 1967).

The BART is a "computerized, laboratory-based measure" (Lejuez et al., 2002, pp 75–76) to assess *decision-making*. A small balloon, which was identical in each trial, was presented on the computer screen. Participants were instructed to press the space bar to inflate the balloon. Each press on the space bar inflated the balloon by one pump. Each balloon had a different randomized bursting point. Participants earned a hypothetical 0.10 Euros for each pump but lost all the money for a given trial if the balloon burst. Participants were instructed to press the space bar as many times as they dared to inflate the balloon. More pumps indicated a higher risk of bursting the balloon but also the possibility for a higher reward. Participants were asked to complete a total of 20 trials. The BART score was computed in terms of the total amount of money earned over all trials. A higher BART score indicated riskier decision-making.

Additionally, we used the HLL (Holt and Laury, 2002) as another measure of *decision-making*. The HLL measures decision-making in the financial domain and consists of 10 independent, randomly presented decision trials. In each trial, participants were asked to decide between two stock options that represented more or less risk. The more risky option was defined as a lower chance of winning a higher amount of money (e.g., winning 385 Euros with a probability of 10% and 10 Euros with a probability of 90%), the less risky option was defined as a higher chance of winning a smaller amount of money (e.g., winning 200 Euros with a probability of 10% and 160 Euros with a probability of 90%). Participants had to weigh the chances of winning and the possible amount of money to be gained, and then make either the risky or the less risky decision. We assigned a score of 1 if participants chose the less risky option and a score of 2 if participants chose the riskier option. An overall risk score for all decisions was summed as a measure of decision-making (HLL Score), with a higher score indicating riskier decision-making. One of the items in the lottery served as a control for careful processing of the task as choosing option 1 indicates careless clicking through the task (option 1: winning 200€ with a probability of 100% and 160€ with a probability of 0%; option 2: winning 385€ with a probability of 100% and 10% with a probability of 0%). Participants who did not work carefully were excluded from the analysis of the HLL, and eight participants (n = 93) were thus excluded.

Concentration

The KONT-P by Satow (2011) was used to measure *concentration* capability in terms of quantity (accuracy and speed) and quality (efficiency). The KONT-P consists of one calculating and one counting subtest. The calculating subtest consisted of simple addition tasks. In the counting subtest, participants had to count the number of times the digit 1 appeared in a row of distracting digits and letters. For each subtest, five pages were presented successively, with seven tasks at a time. Participants were asked to solve as many tasks in 20 s as possible. After 20 s, the next page was forwarded automatically. Participants were told that it was not possible to solve all of the tasks within the restricted time. The KONT-P offers several measures for concentration capability (Satow, 2011): *accuracy, speed, efficiency, accuracy increase,* and *speed increase*. *Accuracy* was defined as the sum of correctly solved tasks; *speed* was defined as the sum of completed tasks. Accuracy and speed were calculated for both subtests as well as for the overall test. *Efficiency* was defined as the ratio between accuracy and speed in the overall test. In addition, *accuracy increase* and *speed increase* throughout the entire test was measured in terms of the difference between accuracy or, respectively, speed in the first half of the test compared to the second half.

Control Variables

To control for confounding effects, we assessed several control variables at the end of the study. As personality has been shown to influence a variety of work outcomes (e.g., Humphreys and Revelle, 1984; Van Yperen et al., 2014) we included several personality factors as control variables that have either been found to affect concentration and decision-making or that can be assumed to interact with the environment or with time pressure. Unless otherwise noted, all items of the personality questionnaires were rated on a five-point Likert scale. *Achievement motivation* was assessed with 10-items derived from the Leistungsmotivationsinventar (LMI-K; Schuler et al., 2001). Higher values indicated higher achievement motivation. *Freedom from constraints* was assessed, as suggested by Steidle and Werth (2013), in terms of subjectively perceived self-regulation (externally controlled vs. self-determined, see Ryan and Deci, 2000) and assertiveness (inhibited vs. self-assured, see Jacobs and Scholl, 2005). Higher values indicated a more autonomous self-regulation. Personality traits in terms of the *Big Five* (openness to experience, conscientiousness, extraversion, agreeableness, neuroticism) were assessed using the 10-item Big Five Inventory (BFI-10; Rammstedt et al., 2013). Higher values indicated a more pronounced manifestation of the trait. *Ambiguity tolerance* was assessed with the Ungewissheitstoleranzskala (UGT) by Dalbert (1999) including eight-items. Higher values indicated greater tolerance of ambiguous situations. *Personal need for structure* was measured with 12-items of the personal need for structure scale (PNS) by Machunsky and Meiser (2006). Higher values indicated a stronger personal need for structure. *Regulatory focus* was measured with the 10-item Regulatory Focus Scale (RFS) by Fellner et al. (2007). Higher values indicated a more promotion-oriented regulatory focus; lower values indicate a more prevention-oriented regulatory focus. *Absorption capacity* was measured with the help of eight-items derived from the Expanded Tellegen Absorption Scale (ETAS) by Smith-Jackson and Klein (1997). Higher values indicated a higher capacity for absorption.

In addition we assessed *evaluation of virtual environment* by means of several questions regarding the virtual reality experience. One-item was implemented to rate *dizziness and nausea* due to the 3D presentation of the virtual environments, higher values indicated stronger physical discomfort. *Immersion* was assessed by five-items derived from the presence questionnaire by Witmer and Singer (1998). Higher values indicated a stronger immersion in the virtual environment. Additionally, three questions regarding *pleasure* ("How much fun have you experienced exploring the 3D environment?," 1 = no fun at all; 7 = a lot of fun), *motivation* ("How motivated have you been during the exploration of the 3D environment?," 1 = no motivation at all; 7 = a lot of motivation), and *feeling* ("How did you feel during the exploration of the 3D environment?," 1 = very bad; 7 = very good) were asked to control for effects of the environment. All items were rated on a **seven**-point Likert scale. Higher values indicated more desirable conditions. Demographic variables of interest were gender and age.

RESULTS

t-Tests for independent samples were computed to investigate differences between two groups. Interaction effects were assessed using univariate variance analyses. Moderation analyses were conducted with the help of PROCESS modeling, as recommended by Hayes (2012). There were no indications of outliers.

Hypotheses 1a and 1b

First, we examined whether there were any simple main effects of the environment on decision-making (Hypothesis 1a) and concentration (Hypothesis 1b), without considering time pressure. We found a marginally significant main effect of the environment on *decision-making* as measured with the HLL, and a significant main effect on *accuracy increase* in the KONT-P. Participants in the work environment (M = 14.19, SD = 1.62) showed marginally significantly riskier *decision-making* behavior compared to participants in the non-work environment (M = 13.65, SD = 1.42), $F(1,92)$ = 2.94, p = 0.090. Further, participants in the work environment (M = 3.60, SD = 3.06) showed a significantly higher *accuracy increase* compared to participants in the non-work environment (M = 2.24, SD = 2.68), $F(1,100)$ = 5.53, p = 0.021. We did not find any other main effects of the environment on decision-making or concentration performance (all other $p > 0.150$).

Hypothesis 2

We assumed that the effects of the environment on decision-making and concentration are moderated by time pressure (Hypothesis 2). We did not find such an interaction between the environment and time pressure (all $p > 0.264$).

We examined whether time pressure alone showed any effects on decision-making and concentration performance. We found two significant main effects of time pressure, and these were on *accuracy* and *speed* in the calculating subtest. Participants in the no time pressure condition (M = 18.61, SD = 3.91) were *more accurate* compared to participants in the time pressure condition (M = 17.17, SD = 3.64), $F(1,100)$ = 4.07, p = 0.046. Further, participants in the no time pressure condition (M = 20.12, SD = 3.94) were *slower* compared to participants in the time pressure condition (M = 18.69, SD = 3.52), $F(1,100)$ = 4.13, p = 0.045. We did not find any other main effect of time pressure on decision-making and concentration performance (all other $p > 0.112$).

Control Variables

Personality Factors

We did not find any *a priori* differences between participants in the work and non-work condition neither for achievement motivation ($p = 0.810$), nor for freedom from constraints ($p = 0.350$), the Big Five (all $p > 0.113$), ambiguity tolerance ($p = 0.309$), personal need for structure ($p = 0.415$), regulatory focus ($p = 0.496$), or absorption capacity ($p = 0.099$).

Evaluation of Virtual Environment

The evocation of nausea due to the 3D-presentation of environments differed with marginal significance between both environments. The work environment ($M = 6.94$, $SD = 0.42$) evoked with marginal significance less nausea compared to the non-work environment ($M = 6.57$, $SD = 1.34$), $t(56.69) = 1.86$, $p = 0.069$. As the mean values for both environments are not very high (note: scale was 1 to 7, with 7 indicating no nausea at all), this result was not a cause for concern. The subjective feeling of immersion did not differ significantly between the work environment ($M = 4.90$, $SD = 0.99$) and the non-work environment ($M = 5.16$, $SD = 1.05$), $t(99) = -1.28$, $p = 0.205$. Thus, environments were constructed in a comparable manner. Regarding pleasure, motivation, and feeling elicited through the virtual environment, the two environments differed significantly. Participants experienced significantly less pleasure in the work environment ($M = 4.25$, $SD = 1.56$) compared to participants in the non-work environment ($M = 5.16$, $SD = 1.30$), $t(99) = -3.19$, $p = 0.002$. Participants also had less motivation to experience the work environment with marginal significance ($M = 5.12$, $SD = 1.58$) compared to participants in the non-work environment ($M = 5.65$, $SD = 1.20$), $t(94.80) = -1.93$, $p = 0.056$. Additionally, participants felt significantly better while experiencing the non-work environment ($M = 5.57$, $SD = 1.34$) compared to the work environment ($M = 4.94$, $SD = 1.23$), $t(99) = -2.46$, $p = 0.015$. We ran several mediation analyses to make sure that these environment-associated variables did not mediate effects of the environment. We did not find any mediation effects of nausea (all $p > 0.250$), immersion (all $p > 0.416$), pleasure (all $p > 0.216$), motivation (all $p > 0.212$), or feeling (all $p > 0.410$), for any of the dependent variables.

DISCUSSION

Summary

This study investigated whether the environment affects decision-making and concentration performance moderated by demands of the task, such as time pressure. We manipulated *environmen*t (work vs. non-work) and *time pressure* (working without vs. with time constraints) to investigate influential effects on decision-making or concentration.

We assumed that a work environment is associated with a work-related schema that would in turn activate cognitive resources and associations related to work behavior (e.g., working with high concentration and daring more), which then in turn would enhance concentration performance or affect decision-making behavior. We found a significant main effect of environment on concentration regarding accuracy increase in the concentration task. As expected, participants in the work environment showed a higher accuracy increase compared to participants in the non-work environment. In addition, we found a marginally significant effect of environment on decision-making when measured with the Holt Laury Lottery. Participants in the work environment made marginally more risky decisions compared to participants in the non-work environment.

In addition, we assumed that time pressure strengthens the effect of the environment on decision-making behavior and concentration performance, as the impact of heuristic cues (e.g., schemata activated by the environment) is stronger when resources (e.g., time) are limited. Time pressure (and therefore experienced stress) is a common challenge in work life (e.g., Blaug et al., 2007; Perlow, 2016) and has been shown to have an impact on cognitive processes and performance (e.g., Lazarus et al., 1952; Mendl, 1999). Time pressure affects information search strategies and decision-making (e.g., Wright, 1974; Ben Zur and Breznitz, 1981; Huber and Kunz, 2007) as well as processing strategies (e.g., Verplanken, 1993; Suri and Monroe, 2003) and performance in general (Andrews and Farris, 1972). However, results in this experiment did not reveal a significant interaction effect between environment and time pressure for any of the dependent variables but two significant main effects emerged for time pressure on accuracy and speed in one of the subtests of the concentration task. Participants who did not experience time pressure worked more accurately and showed slower task processing. This result is consistent with our manipulation check of the time pressure induction, which showed that participants who experienced time pressure did in fact work faster compared to participants who did not experience time pressure. It seems obvious that accuracy might suffer when task processing speed is higher because participants either do not have the time or do not take the time to check each task or trial carefully.

Limitations

By manipulating the environment with the short exploration of a virtual reality, we found effects on subsequent decision-making and concentration performance. Although the effect sizes are modest, these findings provide initial evidence and suggest that the effects of real environments might be stronger.

Several limitations of the study might have dampened the effects, either due to weak points in theory or in the experimental design. Results were not strong enough to confirm the hypothesis that work environments enhance performance in concentration and make decisions riskier compared to non-work environments. On the one hand, it might be possible that we were not able to activate the intended mental schema or that we accidentally caused competing effects besides the ones we intended by means of the environment manipulation. We compared a typical work environment (a traditional office) to only one potential representative of a non-work environment (garden scenery). This brings at least two difficulties. First, we cannot be sure that the presented environments (work vs. non-work) hold equally strong associations with the intended mental schemas (work vs. non-work) we planned to activate by it. Whereas a traditional office might be typical enough to hold associations with work for almost everybody, we do not know whether peaceful garden scenery is associated with a typical non-work environment with the same strength. The presented garden resembles a Tuscan landscape and might not be familiar to every participant. Therefore, we need to consider the possibility that the non-work environment did not activate a sufficiently strong non-work schema for everybody. Second, a large body of research showed that natural environments have benefits on health and well-being as well as cognition through attention restoration (e.g., Largo-Wight et al., 2011; Richardson et al., 2016). For example, Berman et al. (2008) compared cognitive functioning of participants after interacting either with natural or urban environments by means of an actual walk within the environment or by viewing pictures of the environment. Berman et al. (2008) showed that an interaction with natural environments but not urban environments led to improved performance in executive and directed-attention attention tasks. In the Attention Restoration Theory (Kaplan, 1993, 1995) it is stated that natural environments can have restorative effects when directed attention is depleted and information processing might therefore be impaired. It is assumed that natural settings contain modestly captivating stimuli (e.g., a nice flower in the grass) that grab attention during bottom–up processes, while directed attention resources (top–down processes) can be restocked. This should lead to improved performance for subsequent tasks that require high attention. In contrast, urban settings contain acutely attention-grabbing stimuli (e.g., watch where you go and take care of the traffic) that impedes attentional resources to be restocked (Kaplan, 1993, 1995). A large body of research demonstrates these restorative, stress-reducing effects of natural environments (e.g., see review by Korpela et al., 2014). The virtual environments we used to manipulate surroundings to activate related schemas were indeed not comparable regarding natural representations. Whereas the office environment did only contain a small pot plant, the garden scenery consisted almost exclusively of natural elements such as trees, grass, flowers, or a lake. Therefore, we must consider the possibility that the natural stimuli in the non-work environment (garden scenery) did enable restoration effect on cognitive processes which the work environment did not. This restoration effect might have canceled out the intended effects of the non-work schema (e.g., showing less effort in work related activities) and led to a disconfirmation of our initial hypotheses. Future research must control for these potential confounding effects by using different non-work environments in contrast with the work environment. Possible suitable non-work environments should include as many natural elements as the work environment. For example, a room with the same size and architecture as the work-related office room but instead furnished with typical non-work-related items such as a sofa, a TV, or gaming consoles. However, when we designed the reported experiment, we decided to use the garden scenery as a non-work environment as a starting point for this highly complex research area. The goal of future research studies is to refine the design (e.g., through using different gradients of differences between the environments) in order to exclude possible confounders and identify the relevant factors. Furthermore, we found several differences between the work and non-work environments regarding the control variables motivation, pleasure, and feeling. Participants exploring the non-work environment felt better, indicated more pleasure and higher motivation. Although we did not find mediating effects of these control variables, this should be kept in mind when designing comparable work/non-work environments for future research.

In addition, the manipulation of environments might not have been strong enough to elicit sufficient related schemas because of the rather short manipulation time or the characteristics of the laboratory where the experiment took place. The duration of the virtual environment exploration was 5 min the first time and 3 min the second time, which might not have been long enough to activate a strong mental schema. Moreover, participants might have had difficulties to maintain the activated mental schema throughout the course of the experiment. To avoid the extinction of the schema, we tried to keep duration of tests after the exploration as short as possible and repeated the environment manipulation. After conducting the decision-making tasks, a second environment exploration followed which functioned as a mental break to prevent carry-over effects from the decision-making to the concentration task. We randomized items within all tasks, but unfortunately it was not possible to randomize sequence of decision-making and concentration tasks due to the technical restrictions of the BART. Special software is needed to conduct the BART and it was not possible to directly include it in the same survey software as the other measurements as it had to be started manually. However, we cannot make sure that these actions (e.g., short test duration and repeated environment manipulation) were enough to maintain the intended mental schemas throughout the assessment of dependent variables. Participants still sat in the laboratory throughout the experiment, which might have contained additional stimuli that might have counteracted the intended effects. The laboratory resembled a traditional office (and therefore a work environment) in a much stronger way than it resembled a non-work environment, such as a garden. If participants have lifted their heads after exploring the virtual environments or at some point during the experimental course, elements of the laboratory (e.g., desks, computers, work utensils) might have grabbed their attention. These elements might have elicited a concurring mental schema, which in turn might have suppressed especially the activation of a non-work-related schema.

Implications for Future Research

We cannot draw sufficient conclusions from our experiment to support or to contradict these speculations. We assumed that environments activate associated mental schemas but within the current experimental design we were not able to directly measure these mental schemas. We first tried to investigate them in a way that we examined the effects of the mental schema on performance and behavior. As we did not find robust effects, we cannot differentiate whether this lack is due to unsuccessful manipulation (activated mental schemas were not activated in a sufficient way), due to an insufficient theoretical base (environments do not activate related schemas), or whether hypotheses (environments have the potential to affect decision-making and concentration) must be rejected. Future research is needed to unravel these factors and it will be necessary to distinguish the physical from the mental environment (and the schema activated by each) to identify the underlying process. Up to now there is no sound method to measure mental schemas directly. However, one possible way might be to add another method of manipulation to the experimental design: to manipulate work- and non-work environments not only in fact (by means of virtual environments or actual environments) but also by means of priming methods (priming a work-related vs. non-work-related environments). Findings could help to understand, whether effects on performance and behavior might come from the actual environment itself or also from the mere thinking of an environment (and therefore from a mental schema).

In addition, there are several factors that might play an additional role in the relationship between environment and work performance or behavior. For example, work performance is linked to many other factors, such as job satisfaction and organizational commitment (e.g., Shore and Martin, 1989), organizational climate (e.g., Pritchard and Karasick, 1973), opportunities (e.g., Blumberg and Pringle, 1982), as well as individual differences. In everyday life, most of us know examples of successful workers who can block out every noise to work in an atypical environment, for example even on a muggy train or in a crowded café. However, there are also contrary examples of workers who need a tranquil and organized setting to work successfully. Therefore, it seems useful to consider individual characteristics to explain why some people can work under unfavorable conditions and others not. Individual differences should be kept in mind when investigating the influence of the physical environment on work outcomes. Some research has already identified a lengthy list of individual differences that have been shown to affect cognitive processes or decision-making, such as affect (e.g., Clore et al., 2001) or differences in neural correlates (e.g., Pennington, 1994) and individual risk propensity, impulsivity, or sensation seeking (e.g., Zuckerman and Kuhlman, 2000; Lejuez et al., 2002; Nicholson et al., 2005). From a practical perspective, it is crucial to investigate whether there might be individual differences in the capacities of knowledge workers to maintain work performance on an equally satisfying level in different environments and if there are certain personality factors that go into making good, successful workers.

Another important point to discuss is the method we chose to measure work outcomes. Due to practicability and reasonableness, we had to narrow down the large field of work performance and work behavior to only two basic work activities: decision-making and concentration assessed by three tasks. This is of course not enough to give an exhaustive insight in work outcomes. Vischer (2008) criticizes that in workspace research, work performance or work productivity is mostly measured in terms of self-reports. As these might be biased, it is important to use objective indicators as well. We wanted to address this concern and chose to measure decision-making and concentration by means of highly objective, standardized, hard measures and therefore our experiment is one approach to get more holistic insights into the environment–work outcome relationship. However, this poses two challenges. First, it is possible that our measurements have made it especially difficult to find an effect. Effects might not have been strong enough to influence these robust assessments. Results might have looked different if we would have included soft measures, such as self-reports, as well. Second, narrowing down real work outcomes to standardized objective tests involves a reduction in proximity to everyday work life. A standardized concentration task might not exactly reflect typical work tasks that involve high concentration. This holds true for the decision-making tasks as well. Decision-making has been shown to be multidimensional and knowledge workers are confronted daily with multiple decisions from various domains that also depend highly on situational variables. That is why it is very difficult to assess this work behavior in the limitations of only two different tasks (e.g., the BART and the lottery). Extended research is needed to be able to draw conclusions from basic task components and to transfer it to actual work behavior.

At the onset, research in innovative and rarely studied topics necessitate that not all the factors are clear and that changes in the design and method are necessary. The goal of this study was to establish the first insights into the question of whether modalities of modern work such as ubiquitous working (i.e., working in multiple locations) have effects on work performance and work behavior. This experiment was only the first step toward understanding this highly complex subject matter. Future research is needed to understand the process (e.g., whether environments elicit related mental schemas) and to investigate whether results hold true for all types of work settings (besides typical offices vs. garden sceneries), work activities (besides decision-making and concentration), different demands or characteristics of the task (besides time pressure) and for individual personalities.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of the American Psychological Association's ethical principles with written informed consent from all subjects. All subjects gave written informed consent in accordance with the American Psychological Association's ethical principles. The protocol was approved by the Leibniz-Institut für Wissensmedien (IWM) own ethics committee.

AUTHOR CONTRIBUTIONS

All persons who meet authorship criteria are listed as authors, and all authors certify that they have participated sufficiently in the work to take public responsibility for the content, including participation in the concept, design, analysis, writing, or revision of the manuscript.

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Environmental effects on cognition and decision making of knowledge workers

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ABSTRACT

The term ubiquitous working describes the relocation from working in a traditional office on company premises to flexible working in the home or in other environments that were never originally conceptualized for working, such as parks or hotel lobbies. Research indicates that the environment has the potential to influence work performance. We used virtual 3D environments to examine the impact of a work-related (characteristic office) vs. a non-work related context (Tuscan garden) on attention, concentration, and decision making. We assumed that the context would influence cognitive performance. Our results showed that, compared to the non-work context, participants in the work context (1) had marginally faster reaction times in an attentional task (2) were more accurate in completing a concentration test, and (3) made decisions that were more risky. These results suggest that working in a more typical work environment enhances work performance and influences decision making.

1. Introduction

Mobile devices such as notebooks, smartphones, and tablets make accessibility to information possible anytime and anywhere. As a consequence, recent trends toward different forms of work settings lead away from working in a fixed environment. Employees are able to work in multiple, varying environments – in parks and gardens, in hotel lobbies, in cafés, or in the living room at home. A large body of research has already examined how specific features of working environments influence work performance, resulting in suggestions for how to design an office or work space to enhance performance (e.g., Amabile, Conti, Coon, Lazenby, & Herron, 1996; Dul, Ceylan, & Jaspers, 2011; Hill, Ferris, & Märtinson, 2003; Shalley, Zhou, & Oldham, 2004). In this paper, however, we investigate how working in non-work contexts influences task performance.

1.1. Knowledge worker and ubiquitous working

Today, the largest group in the workforce of developed countries are knowledge workers (Drucker, 1999). Knowledge workers work with great autonomy and self-determination (Drucker, 1999). Typical tasks are, for example, acquiring, searching, analysing, and storing knowledge, as well as organizing, planning, and deciding (Ramirez & Nembhard, 2004). Knowledge workers mainly need their cognitive resources for working and are no longer as dependent on specific materials or machines as manual workers decades ago (Kidd, 1994). They just need only a laptop or a smartphone and access to the Internet to be interconnected with their workplace (Sørensen & Gibson, 2004) and to be able to do their work.

Various modern forms of location-independent working have evolved ever since technologies made this flexibility possible (Kurland & Bailey, 1999). Messenger and Gschwind (2015) refer to this development as the "(r)evolution from home office to virtual office": in a first step, working became flexible through the relocation from working in a traditional office on company premises to working from home. Driven by newly developed technologies such as portable computers, work flexibility increased further. Besides the two locations – traditional office and home office – work in third locations became feasible as long as resources such as electricity, printers, or other devices, as well as Internet access were available. Due to further technological developments, however, even those resources are no longer necessary and work has become

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entirely independent of location.

Knowledge work can be done anywhere and anytime or, in other words, work has become ubiquitous (Chen & Nath, 2005; Su & Mark, 2008). Work is no longer done exclusively in traditional work spaces like thoughtfully designed offices, but also in locations that were originally never conceived of as places for office work, such as parks or cafés. This fundamental change of working environment makes it necessary to completely reconsider the concepts of working, work behaviour, and work performance (Halford, 2005).

A lot of research has already dealt with forms of ubiquitous working, mainly focusing on the impact of ubiquitous working on work-life balance, job satisfaction, monetary factors, or social aspects (e.g., Baines, 2002; Koroma, Hyrkkänen, & Vartiainen, 2014; Kurland & Bailey, 1999). However, the impact of ubiquitous working on work performance or productivity has remained unclear (Bailey & Kurland, 2002), although the success of a company mainly depends on the productivity of its knowledge workers (Drucker, 1999). That is why it is important to investigate the work behaviour of knowledge workers and to identify factors that contribute to their productivity.

Investigating the work performance or productivity of knowledge workers is not easy, because the outcome of knowledge workers' productivity is seldom concrete or immediate. For example, knowledge work productivity cannot be measured in terms of number of produced units but has to be regarded more as the quality of an outcome rather than in quantitative terms (Drucker, 1999; Ramirez & Nembhard, 2004). There is no general method to measure knowledge work productivity (Ramirez & Nembhard, 2004), the result of knowledge work could be the solution for a problem (e.g. how to produce green energy), a new product or service idea (e.g. how to design a new smart device), a process (e.g. how to conduct an accused defence), or a decision (e.g. about the feasibility of an investment). In our study we focused on the basic cognitive tasks that underlie such knowledge work. We measured attention, concentration, and decision-making behaviour as indicators for cognitive performance in certain tasks that underlie typical knowledge work.

1.2. Impact of work context

Although many knowledge workers could work ubiquitously, most knowledge workers remain attached to distinct work environments (Kidd, 1994), for example, an office with work desks, shelves, and notepads.

We assume that work behaviour corresponds to specific work contexts, and we further assume that during occupational socialisation and conditioning, people learn a matching schema about those work contexts. A schema is a “cognitive structure that represents knowledge about a concept or type of stimulus, including its attributes and the relations among those attributes […]” (Fiske, 2000, p. 158). Thus being in a work context should activate a schema with related norms (e.g. to knock before entering another persons' office), rules (e.g. do not disturb others with noisy music), goals (e.g. being successful) and behaviours (e.g. avoiding distraction). In contrast, a non-work context (e.g. being in a park, a café, or at home) could possibly be associated with a leisure-related schema that is likely to activate different norms, rules, goals, and behaviours (e.g., being relaxed, to go easy on cognitive resources, to avoid too much mental effort or unpleasant tasks) that are not conducive to successful knowledge work.

Knowledge workers have to evaluate information, solve problems, and make decisions in contexts where others relax and recreate (e.g. during travelling in trains or airplanes, or in hotel lobbies and other public places). Therefore, knowledge workers need high cognitive capacities as well as well-developed problem-solving skills in any environment, but especially in environments which challenge these skills (Kelloway & Barling, 2000; Reinhardt, Schmidt, Sloep, & Drachsler, 2011). They have to activate the appropriate work schema, which is associated with adequate work behaviour (e.g., working with full concentration, being particularly attentive and exerting cognitive capacities) even if they are working in a non-work context. In other words, working in a non-work context is likely to activate a leisure-related schema (e.g., associations of recreation: rest oneself and to do enjoyable things to fill up mental energies), which in turn does not incite typical work behaviour and therefore could diminish cognitive performance.

So far, there has been little research examining the impact of ubiquitous working on cognitive performance. However, it seems justified to assume that cognitive performance would not be the same in different environments. If performance changes depending on the environment, it should be reconsidered whether working ubiquitously is useful at all. Or, the other way around, successful ubiquitous working might depend on the ability to activate a schema appropriate to a particular environment.

Does a professional work as effectively in a park or a café as in the office? If not, can different environments be utilized intentionally to foster certain types of cognitive performance? It is necessary to discuss how organizations can facilitate ubiquitous working, for example by providing digital social information spaces (Matschke, Moskaliuk, Bokhorst, Schümmer, & Cress, 2014) that enable web-based construction and exchange of knowledge.

In the following experiment, we investigated whether cognitive performance depends on a given work context. We used a virtual 3D environment to prime the context (work vs. non-work). Participants browsed through a virtual 3D environment representing either a characteristic office (work context; to activate a work-related schema) or a garden within Tuscan scenery (non-work context; to activate a leisure-related schema). The two contexts were used to activate different cognitive schemas. They did not differ with regard to objective qualities like noise, disturbances or the like. We measured *attention, concentration*, and *decision-making behaviour* to test our hypothesis that the contexts would influence performance differently.

1.3. Context priming

By priming participants in an experiment with a specific context, it is possible to shape which schema is activated and therefore which sort of cognitive processing style is used. That, in turn, influences performance (Förster, Friedman, Butterbach, & Sassenberg, 2005; Goclowska, Baas, Crisp, & De Dreu, 2014). A large body of research deals with priming effects on cognition. For example, Dijksterhuis and van Knippenberg (1998) showed that priming participants with the stereotype ‘professor’ led to enhanced performance in a general knowledge test. Thus, it is possible to influence even complex behaviour with the help of priming, and these effects of priming on cognition are quite stable (Dijksterhuis & van Knippenberg, 1998). It has been demonstrated that cognitive processing and behaviour could be shaped when participants were primed with stereotypes, but also with traits, objects, clothing, motor actions, or even brand names (Dijksterhuis & van Knippenberg, 1998; Fitzsimons, Chartrand, & Fitzsimons, 2008; Friedman & Förster, 2000; Kay, Wheeler, Bargh, & Ross, 2004; Slepian, Ferber, Gold, & Rutchick, 2015; Slepian, Weisbuch, Rutchick, Newman, & Ambady, 2010).

Smith and Vela (2001) stated that the stimuli of an environmental context are encoded and processed automatically without conscious activity. Physical characteristics of an environment and specific context stimuli may act as priming factors and influence cognition and processing styles. This has already been demonstrated, for example, for lighting conditions (Steidle & Werth, 2013), office compositions, spatial configurations, and space designs (Aiello, DeRisi, Epstein, & Karlin, 1977; Block & Stokes, 1989; Shalley et al., 2004), as well as for natural views (Tennessen & Cimprich, 1995). Especially creativity researchers have invested much effort into identifying specific environmental characteristics that foster divergent cognitive processing styles and thereby creative performance (De Alencar & Bruno-Faria, 1997; Dul & Ceylan, 2011; Dul et al., 2011; McCoy & Evans, 2002). It has been shown as well that certain environments or contexts have different effects on certain tasks. The context must fit the demands of the task in order to be beneficial for task performance. For example, contexts that offer more stimulation foster performance in routine tasks, whereas contexts with little distraction foster performance in more complex tasks (Block & Stokes, 1989; Larsen, Adams, Deal, Kweon, & Tyler, 1998; Stone & English, 1998; Stone & Irvine, 1994).

It is still being discussed which processes mediate the influence of context on cognition. One approach is that certain contexts or environments activate certain associated processing styles, which in turn influence cognitive processes. For example, Slepian et al. (2010) assumed that the mere presence of a lightbulb would influence the cognitive performance of participants, as the image of a lightbulb is generally associated with the concept of insight. Participants did indeed perform better with insight tasks when a lightbulb was present, compared to conditions where no lightbulb was present. Kay et al. (2004) found a similar effect with the presence of objects that are related to the concept 'business', such as briefcases or suits. These kinds of business-related objects are generally associated with competitive behaviour. Participants in fact showed more competitive behaviour in conditions in which business-related objects were present, compared to conditions in which no such objects were present – suggesting that these objects led to the activation of a competition schema.

Steidle and Werth (2013) provide another explanatory approach. They suggest that individuals subjectively perceive the physical characteristics and atmospheric features of an environment as a visual message. The visual message can come across, for example, in terms of feelings like freedom and autonomy or perhaps threat and insecurity, and the message in turn influences cognitive processes and performance (Steidle & Werth, 2013; Steidle, Werth, & Hanke, 2011). In line with these suggestions, the assumption that the context does influence cognition seems to be justified: characteristics of the context might activate specific schemas with related cognitive processing styles.

Research concerning context effects on work performance has only been conducted with regard to different kinds of work-related environments, such as traditional, virtual, or home offices (Hill et al., 2003). But to our knowledge no research has dealt with the impact of non-work-related contexts on work performance. In particular, there has been no research done addressing the question as to whether there is a difference in cognition between working in a work-related environment (work context), like an office, compared to working in a non-work-related environment (non-work context), like in a park or at a holiday resort. For this reason we have investigated in the present experiment how this context priming (work vs. non-work) influences cognitive performance.

1.4. Cognitive performance

Cognition is a collective term for conscious and unconscious mental processes that are needed for perception, thinking, decision making, and action control (Wirtz, 2013). Attention and concentration are two relevant measures of cognition and cognitive performance (Wirtz, 2013). Attention is the ability to select relevant information and direct the mind actively to a relevant stimulus while ignoring distracting information, in order to be able to use this relevant information for perception, thinking, to control actions, and to interact with the environment (Castle & Buckler, 2009; Wirtz, 2013). Concentration is a state of being totally immersed in a thought or action (e.g., Castle & Buckler, 2009). This mental state is influenced by external and internal cognitive, emotional, motivational, and social factors. Concentration can also be regarded as an individual factor in terms of the capability of an individual to concentrate (Wirtz, 2013).

Attention and concentration are preconditions for successful learning, problem solving, and decision making (e.g., Duval, 2011; Schmidt, 1995; Wirtz, 2013), and therefore relevant cognitive resources for successful knowledge work. Attention and concentration are work-related cognitive processes, and thus performance should be enhanced when performed in a work-related environment. Typical work-related environments and work contexts such as traditional office settings are closely related to a work schema that is, in turn, associated with work-related behaviours that demand cognitive resources (e.g., attention and concentration). A work context can therefore facilitate the provision of work-related cognitive resources. This results in better cognitive performance by means of better attention and concentration capability.

These assumptions lead to the following hypotheses:

H1. A work context enhances attention. Therefore, participants who are primed with a work context show better attention capability compared to participants who are primed with a non-work context.

H2. A work context enhances concentration. Therefore, participants who are primed with a work context show better concentration capability compared to participants who are primed with a non-work context.

1.5. Decision-making behaviour

Work performance cannot be reduced solely to basic cognitive performance indicators (such as attention or concentration capacity). That is why we additionally investigate context effects on another indicator of ubiquitous workers' performance: decision-making behaviour in terms of risk aversion. Risk aversion is defined as a certain tendency to make decisions that avoid options that are related to insecure outcomes, which can be assessed by means of lotteries (e.g., Holt Laury Lottery, Holt & Laury, 2002). The willingness to take risks is a crucial factor for organizational success (MacCrimmon & Wehrung, 1988). Does a professional make more risky decisions in a specific context than in another context? A lot of findings indicate that decision making – just like cognitive processes – can be influenced by certain conditions or priming factors. For example, emphasizing either failure or gain influences decisions (Arkes, Herren, & Isen, 1988; Kuhberger, 1998). Risk aversion differs widely in different situations (MacCrimmon & Wehrung, 1988). We expect that context will influence decision making as well. People show less risk aversion and make more risky decisions when those decisions are associated with their work, compared to decisions that affect their private life (MacCrimmon & Wehrung, 1988; March & Shapira, 1987). People are more willing to take risks in work-related decisions than in personal decisions because the responsibility for a possible unfavourable outcome is diffused in the work context but more fatal in the personal context. That means people differ in risk aversion depending upon whether their current role is work related vs. private (MacCrimmon & Wehrung, 1988). We assume that the work context activates a work-related role, and the non-work context activates a leisure-related, thus private role, and that these roles activate in turn either a work-related or a non-work-related processing style. Therefore, we predict that people will show less risk aversive decision-making behaviour in the work context compared to the non-work context.

These assumptions lead to hypothesis 3.

H3. Work context leads to risky decision-making behaviour. Therefore, participants that are primed with a work context show less risk aversion than participants that were primed with a non-work context.

2. Method

2.1. Design

We conducted an experiment with two experimental conditions using two different 3D-environments. In the non-work context condition, participants browsed through a garden resembling a Tuscan landscape showing peaceful nature. Participants were able to walk around the cottage house and to look through the window, but it was not possible to enter and walk through the building. In the work context condition, the virtual environment consisted of office equipment, like a desk, a laptop, and other typical work-related artefacts from an office setting (see Fig. 1). Participants did only see the interior space of the office, but were able to look through the window showing a blurred vision of a street. We presented the 3D-environments on a computer screen. The participants navigated freely through the 3D-environment via mouse and arrow keys. Using the virtual 3D environment allows us to compare two different contexts in an experimental setting while controlling for confounding factors. As dependent variables, we measured in subsequent tasks *attention* capability, *decision-making behaviour*, and *concentration.*

2.2. Participants

Sixty-two people volunteered to participate in the study. Four participants had to be excluded from the analysis due to missing data caused by technical problems. The remaining 58 participants were between 19 and 34 years old ($M = 24.17$, $SD = 3.71$), 11 were male and 47 female. Participants were randomly assigned to either the non-work context condition ($n = 30$) or the work context condition ($n = 28$). Volunteers were paid 8 € for participation or participated in exchange for course credit.

2.3. Procedure

Each participant sat in the same room at an individual computer. Maximally six people participated simultaneously, always separated by cubicles. Participants received a hand-out with instructions in printed form after they had signed an informed consent form. To manipulate the context, participants were requested to put themselves into the subsequently presented virtual 3D-environment (work vs. non-work) and imagine how it would feel being there and how they would spend their time (e.g. written instruction for the office environment: “in the following you will be able to navigate through a virtual office. Please look around, explore the environment and put yourself into the situation. Imagine that you will spend the next several hours in that place: what will you do? How will it feel? Please take your time. The investigator will inform you as soon as the time is up.”). They were given five minutes to navigate freely through the virtual 3D-environment presented on a standard desktop computer using a mouse and keyboard. Additionally, a large poster of either the office (work context) or the Tuscany scenery (non-work context) was hung up on the wall to remind the participants of the explored environment during the subsequent measurements, in order to maintain the primed context. All of the subsequent tasks and questionnaires were completed on the computer and did not differ between experimental groups. Participants read a short introduction to the survey and started with a lexical decision task, which measured *attention*. Afterwards they were given another three minutes to navigate through the 3D-environment. This was followed by the Holy Laury Lottery with which we assessed risky *decision making*, the Psychomeda Konzentrationstest assessing *concentration,* the logical numbers task of the I-S-T 2000 R assessing *numerical intelligence,* and four questionnaires assessing *achievement motivation, perceived freedom from constraints, evaluation of the 3D-environment,* and *demographics.* To finish the survey, participants were asked if they had any presumptions concerning the hypotheses behind the study. After completing the study, participants were debriefed about the background and goals of the study. They could also generate a personal code to be able to withdraw consent for the anonymous use of their data after the study (for an overview of procedure see Fig. 2, for detailed information about measures see Section 2.4).

2.4. Dependent variables

2.4.1. Attention

We assessed reaction times within a lexical decision task (LDT) to measure *attention*. The task was to classify letter strings as words or non-words, and the lexical decisions required individuals to encode and subsequently compare a presented letter string with words stored in their semantic memory. This processing demands attention, which is demonstrated by research showing that performance in lexical decisions is a) faster for words that are more frequent and thus are more easily accessible (i.e., the base frequency effect; McCann, Besner, & Davelaar, 1988), b) improved through attention training (Fisk, Cooper, Hertzog, Batsakes, & Mead, 1996), or c) diminished when participants' attention is distracted from the ongoing LDT (i.e., when cognitive load is high;

Fig. 1. Screenshots of the non-work-related (a) and the work-related (b) 3D-environments used to activate related schemas.

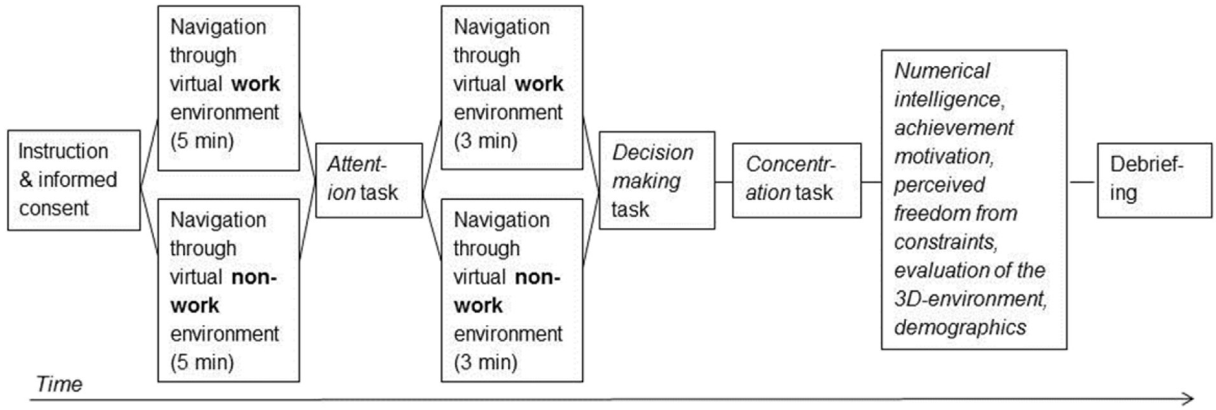

Fig. 2. Flow chart of the procedure of the current study.

Cohen, 2013; Cohen, Jaudas, & Gollwitzer, 2008).

In our version of the task, participants were presented 120 different letter strings and were asked to decide as fast and accurately as possible whether the letter string represented an existing German word or not. A centered fixation cross was presented for 400 ms, before a black screen appeared for 15 ms, followed by a letter string. After the lexical decision was made, the screen went black for 500 ms before the next trial began. The order of trials was randomized. Half of the trials displayed non-words (e.g., Nedopul, Tene, Werbalen), the other half displayed existing German words. These words were either control words (e.g., residents, mountain, spotlight; original: Bewohner, Berg, Scheinwerfer), work-related words (e.g., colleagues, salary, desk; original: Kollegen, Lohn, Schreibtisch) or non-work-related words (e.g., friends, sport, hobby; original: Freunde, Sport, Hobby). Through the choice of the words we additionally wanted to examine whether work-related words were more accessible in the work context condition, and whether non-work-related words were more accessible in the non-work context condition. Control words were balanced for length and valence to the work- and non-work-related words, respectively. We assessed reaction time for identifying existing words as an indicator for *attention*.

2.4.2. Decision making

We used the Holt Laury Lottery (Holt & Laury, 2002) to assess *decision making*. Participants were instructed to imagine working in a company and making decisions about stock options. Ten independent choices with decreasing risk were presented for each choice. Participants were asked to decide between two investment options, a risky (low chance of gain but with a higher amount of money) versus a less risky one (high chance of gain but with a smaller amount of money). Choosing the riskier option was counted as a score of 2, choosing the less risky option was counted as 1. Scores for all ten decisions were summed up as an assessment of *decision making*. Thus, a higher score meant riskier behaviour. Another measurement was computed using the Lottery: the first time a person changed from a less risky to a riskier choice provided another score for decision making (*first change in decision making*). The options got less risky in the course of the ten tasks of the Lottery. Thus, an earlier change (from choosing a less risky option to choosing a riskier option) in the course of the tasks was scored as a more risky decision-making behaviour.

2.4.3. Concentration

We used the Psychomeda Konzentrationstest (KONT-P) by Satow (2011) to measure *concentration* capability, with regard to both quality (*efficiency*) and quantity (*speed*). The test consisted of two subtests. Participants started with the calculating subtest and were instructed to solve as many addition tasks as possible within 20 s on each of the five pages given to them (e.g., $1+1+1+1+1=\_$; solution is 5 in this case). After 20 s the next page was presented automatically. Each page included seven different equations. It was emphasized that it was not possible to solve all of the equations within the restricted time and that participants should focus on efficiency. The counting subtest of the concentration test followed in the same manner. Participants were instructed to count how often the digit 1 appeared in a row of distracting digits and letters, as accurately as possible within 20 s for each of five pages (e.g., i 1 i 1 i 2 i 1 1 i 1 1; solution is 6 times in this case). We calculated the sum of correctly solved tasks (*accuracy*) and the sum of completed tasks (*speed*) for the calculating and the counting subtests, as well as for the overall test. In addition we calculated an *efficiency* score (the ratio between accuracy and speed), *accuracy increase,* and *speed increase* by looking at the difference between correctly solved or completed tasks in the first half of the test compared to the second half.

2.5. Context manipulation

To control for the priming conditions, an *evaluation of the virtual 3D-environment* was made by means of control questions concerning pleasure, motivation, and feeling, as suggested by Steidle and Werth (2013), and questions regarding *nausea* due to the 3D-experience. Each question was answered using a 7-point scale. Higher values indicated more desirable conditions (e.g., 1 = definitely no pleasure, 10 = very much pleasure). In addition, the mean value derived from five items from the presence questionnaire by Witmer and Singer (1998) was used to assess the subjective experience of being in the virtual 3D-environment: *immersion*. Participants rated their agreement on a 7-point scale (e.g., my experience within the 3D-environment complied with my experience within the real world; 1 = does not apply at all; 10 = does definitely apply). Higher values indicated a stronger immersion in the 3D-environment.

2.6. Control variables

Several data concerning personal characteristics served as control variables. *Achievement motivation* was assessed as a personality trait and was computed as a mean value derived from ten items taken from the Leistungsmotivationsinventar (LMI-K) by Schuler, Proschaska, and Frintrup (2001). Participants were requested to rate their agreement with each of ten statements on a 7-point scale (e.g., “It would make me proud if I knew, that I had mastered a difficult task”; 1 = does not apply at all; 10 = does definitely apply). Higher values indicated higher achievement motivation. The individual disposition achievement motivation did not differ significantly between participants in the work context (M = 4.79, SD = 1.10) and the non-work context (M = 4.74, SD = 0.73) condition, $t(56) = 0.83$, $p = 0.828$, $d = -0.06$. Thus, there was no general difference in achievement motivation between the two contexts.

Furthermore, we used the logical numbers task of the Intelligence Structure Test I-S-T 2000 R (Liepmann, Beauducel, Brocke, & Amthauer, 2007) as a measure for *numerical intelligence*. Participants were instructed to complete as many number sequences as possible within 5 min. The task was to continue a number sequence with one more digit by understanding the logic behind the sequence— for example, by recognizing that adding 3 to the preceding number yields the subsequent number in the number sequence: 2 5 8 11 14 17 __ (the sought-for number is 20 in this case). A total of 20 number sequences were displayed on each page. It was clarified that it was not possible to solve all of the sequences within the restricted time. Prior to the actual start, two examples were presented so that participants would understand the task. We calculated the sum of correctly solved tasks (*accuracy*) and the sum of completed tasks (*speed*). The *accuracy* in performing the number sequence task of the I-S-T 2000 R did not differ significantly between the work context ($M = 9.79$, $SD = 4.03$) and the non-work context (M = 8.80, SD = 4.09) condition, $t(56) = 0.924$, $p = 0.360$, $d = -0.24$. The difference in *speed* of performing the number sequence task was also not significant between the work context (M = 10.68, SD = 3.93) and the non-work context (M = 10.27, SD = 3.82) condition, $t(56) = 0.41$, $p = 0.687$, $d = -0.11$. Thus, there was no general difference in this single measure for the participants' numerical intelligence in the work context and the non-work context condition. It can be assumed that results regarding performance in the attention, concentration, and decision-making test are not confounded with effects of context group differences in this single measure of numerical intelligence.

Perceived freedom from constraints was assessed as described by Steidle and Werth (2013). Participants rated how they perceived their own self-regulation (externally controlled vs. self-determined; see Ryan & Deci, 2000) and assertiveness (inhibited vs. self-assured; see Jacobs & Scholl, 2005), each in the form of a five-point semantic differential scale. Higher values indicated more autonomous self-regulation. Perceived freedom from constraints did not differ significantly between participants in the work context (M = 4.02, SD = 0.78) and the non-work context (M = 3.73, SD = 0.92) condition, $t(56) = 0.1.27$, $p = 0.209$, $d = -0.33$. Thus, both contexts elicited a comparable perception of freedom from constraints.

Demographic variables of interest were gender and age. Regarding gender, there was only one significant difference throughout all of the measurements. The difference in accuracy in performing the number sequence task between males (M = 11.45, SD = 4.23) and females (M = 8.76, SD = 3.89), $t(56) = 2.03$, $p = 0.047$, d = −0.68 reached significance. A general superiority of males in numerical intelligence is not surprising and has been demonstrated in several other studies (e.g., Rammstedt & Rammsayer, 2000; Steinmayr, Beauducel, & Spinath, 2010). No other dependent variables differed significantly between male and female participants (all $p > 0.143$). However, as male and female participants were not evenly distributed across the conditions (note: a large majority of the participants was female) we cannot make a clear statement regarding gender effects.

3. Results

Assumptions of normal distribution were tested via Kolmogorov-Smirnov-Test (Lilliefors Significance Correction). If the assumptions for parametric testing were met, a t-test for independent samples was computed to investigate differences between two groups. If assumptions were not met, the non-parametric Independent-Samples Mann-Whitney test was implemented. To investigate interaction effects of two factors, a mixed-design analysis of variance model was used. Mediation analyses were conducted with the help of Process Modeling, as recommended by Hayes (2012). Exclusions of outliers did not change any significance of results.

3.1. Attention

Attention was measured via reaction times (in milliseconds = ms) within the LDT. We excluded latencies from false answers, as well as from answers that were faster than 100 ms, to eliminate fast guesses. Reaction times slower than 1079 ms (i.e., 3 standard deviations above the mean = 572 ms) were cut off at this value to control for slow outliers. One participant with missing data caused by technical problems, as well as one participant with more than 15 mistakes in the LDT (i.e., more than 3 standard deviations above the mean = 4.77 mistakes) were excluded from the following analysis.

We assumed that a work context would enhance attention compared to a non-work context (H1). Based on this assumption, we expected participants in the work context condition to make faster correct decisions in the LDT (that required attention) compared to participants in the non-work context. To test this prediction, we entered reaction times (in milliseconds) for existing words into a 2 (context condition: work vs. non-work) x 3 (word condition: work-related vs. non-work-related vs. control) mixed ANOVA with repeated measures on the latter factor. Results revealed that reaction times in the work context (M = 518 ms, SD = 11 ms) and the non-work context (M = 544 ms, SD = 11 ms) conditions differed only marginally significantly, $F(1, 54) = 2.88$, $p = 0.095$, η^2part. = 0.051.

Beyond that, there was a significant main effect for word condition, $F(2, 53) = 19.84$, $p < 0.001$, η^2part. = 0.269. Participants responded significantly faster to non-work related words (M = 517 ms, SD = 8 ms) compared to work-related words (M = 530 ms, SD = 7 ms), whereby reactions for both of these word categories were, in turn, significantly faster compared to control words (M = 546 ms, SD = 9 ms). This finding indicates a clear ranking order in accessibility of the three word categories, which does not seem very surprising, given that non-work related words (like friends and hobby) would be more positively connoted than work-related words (like salary and desk). However, work-related words also seem to be more accessible than our control words, indicating a certain relevance and frequency of work-related words as well. The interaction between the two context conditions (work vs. non-work) and the three word conditions (work-related, non-work-related, control) did not reach significance, $F(2, 53) = 0.26$, $p = 0.769$, η^2part. = 0.005. Therefore, the accessibility of work- and non-work-related words did not differ between context conditions, which might be due to a potentially high association between work and non-work semantics.

3.2. Decision making

We predicted that participants would make riskier decisions in the work context condition (and therefore show less risk aversion in the Holt Laury lottery) than participants in the non-work context condition (H3). Indeed, *decision making* in the work context condition ($M = 15.25$, $SD = 1.96$) differed significantly from the non-work context condition ($M = 14.17$, $SD = 1.82$), $U = 272.00$, $z = -2.33$, $p = 0.020$, which yielded a moderate effect size $d = -0.57$. Participants in the work context showed a more risky decision-making behaviour compared to participants in the non-work context. The *first change in decision making* differed only marginally significantly between the work context ($M = 4.64$, $SD = 2.39$) and non-work context conditions ($M = 5.73$, $SD = 2.63$), $U = 528.00$, $z = 1.69$, $p = 0.090$, $d = 0.43$.

Analyses of decision making were run a second time with the exclusion of participants whose decisions indicated carelessness in task completion. Not choosing the riskier option in the last task of the lottery might have indicated that the participant did not complete the task carefully (note that the less risky option was a 100% chance of gaining 200€ and the riskier choice was a 100% chance of gaining 385€). After the exclusion of 9 participants, 26 participants remained in the work context condition and 27 participants in the non-work context condition (N = 53). With this reduced sample, differences in *decision making* between work context ($M = 15.54$, $SD = 1.65$) and non-work context ($M = 14.26$, $SD = 1.89$) were still significant, $U = 212.50$, $z = -2.50$, $p = 0.013$, $d = -0.72$, with participants in the work context making more risky decisions compared to participants in the non-work context. Differences between the two contexts in *first change in decision making* did show statistical significance as well, $U = 469.50$, $z = 2.13$, $p = 0.034$ (work context: $M = 4.73$, $SD = 2.26$; non-work context: $M = 6.07$, $SD = 2.54$), $d = 0.56$. Thus participants in the work context changed sooner to a more risky decision-making behaviour. Taken together, results support our hypothesis (H3): participants in the work context condition showed significantly less risk aversion and therefore made riskier decisions compared to participants in the non-work context condition.

3.3. Concentration

We assumed that work context would enhance concentration (H2). According to our hypothesis, participants in the work context should show better *concentration* capability compared to participants in the non-work context.

3.3.1. KONT-P calculating subtest

The *accuracy* in performing the calculating subtest of the KONT-P did not differ significantly between the work context ($M = 17.54$, $SD = 3.28$) and non-work context ($M = 17.13$, $SD = 3.83$) conditions, $t(56) = 0.428$, $p = 0.670$, $d = -0.11$. Similarly, the *speed* in performing the calculating subtest of the KONT-P did not differ significantly between the work context ($M = 19.21$, $SD = 3.37$) and the non-work context ($M = 18.50$, $SD = 4.25$) conditions, $U = 345.00$, $z = -1.17$, $p = 0.241$, $d = -0.19$.

3.3.2. KONT-P counting subtest

However, the *accuracy* in performing the counting subtest of the KONT-P did differ significantly between the work context ($M = 13.43$, $SD = 2.63$) and non-work context ($M = 11.33$, $SD = 4.35$) conditions, $t(56) = 2.20$, $p = 0.032$, which represented a moderately sized effect $d = -0.58$. Participants in the work context were more accurate compared to participants in the non-work context. The difference in *speed* of performing the counting subtest of the KONT-P showed marginal significance between work context ($M = 27.68$, $SD = 1.83$) and non-work context ($M = 26.87$, $SD = 1.80$) conditions, $t(56) = 1.71$, $p = 0.93$, $d = -0.45$. Participants in the work context were marginally faster in completing the task compared to participants in the non-work context.

3.3.3. Overall KONT-P

Taking together the counting and the calculating subtests of the KONT-P, the difference of *accuracy* between the work context ($M = 30.96$, $SD = 5.13$) and non-work context ($M = 28.47$, $SD = 6.98$) conditions showed marginal significance, $U = 312.00$, $z = -1.68$, $p = 0.092$ with a small to moderately sized effect, $d = -0.41$, indicating that participants in the work context were marginally more accurate compared to participants in the non-work context. *Speed* of performing the overall KONT-P did not differ significantly between the work context ($M = 46.89$, $SD = 4.8$) and non-work context ($M = 45.37$, $SD = 5.38$) conditions, $t(56) = 1.14$, $p = 0.260$, $d = -0.30$. *Efficiency* in performing the KONT-P did differ marginally significantly between the work context ($M = 0.66$, $SD = 0.06$) and non-work context ($M = 0.62$, $SD = 0.09$) conditions, $t(56) = 1.77$, $p = 0.082$, $d = -0.46$, indicating that participants in the work context were marginally more efficient in performing the task. *Accuracy increase* during the overall concentration task did not show a significant difference between the work context ($M = 2.61$, $SD = 2.42$) and non-work context ($M = 3.00$, $SD = 2.32$) conditions, $U = 459.00$, $z = 0.62$, $p = 0.538$, $d = 0.17$. But *speed increase* during the overall concentration task did show a significant difference between the work context ($M = 15.68$, $SD = 2.29$) and non-work context ($M = 17.63$, $SD = 2.62$) conditions, $t(56) = -3.01$, $p = 0.004$. This represented a large-sized effect $d = 0.77$, participants in the non-work context showed greater *speed increase* during the course of the whole concentration task compared to participants in the work context.

In sum, results do not support our hypothesis (H2). There was no general superiority in concentration capability between the two context conditions, differences occurred merely regarding single measures.

3.4. Virtual environments

The feeling of *immersion* did not differ significantly between the work context ($M = 4.43$, $SD = 1.13$) and the non-work context ($M = 4.90$, $SD = 1.04$) conditions, $t(56) = -1.66$, $p = 0.103$, $d = 0.44$. As mean values for both contexts were quite high (note: immersion was measured on a scale from 1 to 7), we can assume that closeness to reality was created in both 3D environments. *Nausea* also did not differ significantly between work context ($M = 6.50$, $SD = 1.23$) and non-work context ($M = 6.00$, $SD = 1.89$), $t(50.19) = 1.20$, $p = 0.236$. This indicates that both 3D-environments have been constructed appropriately and in a comparably real-life and immersive manner.

Evaluation of the 3D-environment did differ in some aspects between conditions: pleasure differed significantly between the work context ($M = 4.14$, $SD = 1.51$) and the non-work context ($M = 5.47$, $SD = 1.25$) conditions, $U = 629.00$, $z = 3.32$, $p = 0.001$. This represented a large-sized effect $d = 0.96$. Motivation in navigating through the 3D-environment differed significantly between the work context ($M = 4.89$, $SD = 1.42$) and the non-work context ($M = 5.80$, $SD = 0.96$) conditions, $U = 581.50$, $z = 2.61$, $p = 0.009$. This also represented a large-sized effect $d = 0.76$. Feeling also differed significantly between the work context ($M = 4.43$, $SD = 1.48$) and the non-work context ($M = 5.73$, $SD = 1.08$) conditions, $U = 635.00$, $z = 3.42$, $p = 0.001$. This represented a large-sized effect as well, $d = 1.1$. To make sure that differences in pleasure, motivation, and feeling between the work and non-work contexts did not account for the effects of context on dependent variables, mediation analyses were conducted. Motivation (all $p > 0.244$) and feeling (all $p > 0.129$) did not significantly mediate the effect of context on measures of *attention, concentration*, or *decision making*. Pleasure did show a marginally significant mediation effect on just one measure (for *speed* in the KONT-P counting subtest, $p = 0.083$, 95% CI [−0.040, 0.628]), but as the confidence interval includes zero this effect should not be interpreted as being relevant. There was no significant mediation effect of pleasure on any other dependent variables (all $p > 0.107$).

3.5. Interactions with individual variations (exploratory analyses)

We conducted several multiple linear regressions, and in addition to our experimental factor, included the control variables *achievement motivation, numerical intelligence*, and *freedom from constraints* to test whether they are predictors for *attention, concentration*, and *decision making*, or whether there are any interaction effects. Only significant models are reported.

3.5.1. Predictors of decision making

A significant model was found for predicting *decision making* with the experimental factor *context* and the individual disposition *achievement motivation* (AM), $F(3, 54) = 5.54$, $p = 0.002$, $R^2 = 0.24$. Results are displayed in Table 1a. The work (compared to the non-work) context as well as higher achievement motivation led to riskier decision making. Further, the significant interaction showed that higher achievement motivation strengthened the enhancing effect of the work context on risky decision making: for participants with high achievement motivation (one standard deviation above the mean), the work context led to riskier decision making compared to the non-work context. In contrast, the effect was inverted for participants with low achievement motivation (one standard deviation below the mean): in this case, the non-work context led to riskier decision making. Likewise, the model predicting *decision making* with the experimental factor *context* and the individual disposition *freedom from constraints* (Ffc) was significant, $F(3, 54) = 5.34$, $p = 0.003$, $R^2 = 0.23$ (see Table 1b). Work context and greater freedom from constraints led to riskier decision making. Furthermore, the significant interaction showed that greater freedom from constraints strengthened the enhancing effect of work-context on risky decision making, leading to riskier decision making in the work context compared to the non-work context. The effect was inverted for a lower degree of freedom from constraints: in this case, the non-work context led to riskier decision making.

For predicting *first change in decision making*, a model with *context* and *achievement motivation* reached significance, $F(3, 54) = 5.28$, $p = 0.003$, $R^2 = 0.23$ (see Table 2). Work context significantly led to an earlier first change in decision making. The significant interaction showed that high achievement motivation led to an earlier first change in decision making in the work context (indicating more risky decision making) compared to the non-work context. Low achievement motivation dampened the effect and reversely led to a later first change in the work context compared to the non-work context.

Table 1
Linear models for predicting *decision making*.

	B (CI_l; CI_h)	*SE B*	β	t[a]	Sig. (p)
a. Context & achievement motivation (AM)					
$R^2 = 0.24$, $p = 0.002$					
Constant	10.84 (7.77; 13.92)	1.54		7.10	$p = 0.000$
Context	6.60 (1.34; 11.85)	2.62	1.71	2.52	$p = 0.015$
AM	2.53 (0.99; 4.07)	0.77	1.18	2.94	$p = 0.002$
Context × AM	−1.61 (−2.70; −0.52)	0.54	−2.22	−2.97	$p = 0.004$
b. Context & freedom from constraints (Ffc)					
$R^2 = 0.23$, $p = 0.003$					
Constant	9.59 (6.01; 13.17)	1.78		5.37	$p = 0.000$
Context	4.14 (−0.37; 8.65)	2.25	1.07	1.84	$p = 0.071$
Ffc	1.41 (0.53; 2.28)	0.44	0.62	3.23	$p = 0.002$
Context × Ffc	−1.29 (−2.42; −0.16)	0.56	−1.49	−2.30	$p = 0.026$

Note.
B = unstandardized beta coefficient, CI_l = lower confidence interval, CI_h = higher confidence interval, *SE B* = standard error, β = standardized beta coefficient, t = t-test statistic, p = significance value, R^2 = explained variation.
[a] Degrees of freedom: 57.

Table 2
Linear model for predicting *first change in decision making*.

	B (CI_l; CI_h)	*SE B*	β	t[a]	Sig. (p)
Context & achievement motivation (AM)					
$R^2 = 0.23$, $p = 0.003$					
Constant	4.90 (0.85; 8.96)	2.02		2.43	$p = 0.000$
Context	−8.98 (−15.91; −2.06)	3.45	−1.77	−2.60	$p = 0.012$
AM	−0.06 (−0.88; 0.77)	−0.41	−0.02	−0.13	$p = 0.895$
Context × AM	2.13 (0.69; 3.56)	0.72	2.24	2.97	$p = 0.004$

Note.
B = unstandardized beta coefficient, CI_l = lower confidence interval, CI_h = higher confidence interval, *SE B* = standard error, β = standardized beta coefficient, t = t-test statistic, p = significance value, R^2 = explained variation.
[a] Degrees of freedom: 57.

3.5.2. Predictors of concentration

Accuracy in performing the number sequence task of the I-S-T 2000 R was used as a measure for *numerical intelligence*. This measure showed several interactions with the context in the prediction of concentration (KONT-P). Significant regression equations were found for *accuracy* in the calculating subtest, $F(3, 54) = 7.78$, $p < 0.001$, $R^2 = 0.30$, overall test *accuracy* $F(3, 54) = 9.60$, $p < 0.001$, $R^2 = 0.35$, and overall test *efficiency*, $F(3, 54) = 7.07$, $p < 0.001$, $R^2 = 0.28$. Results are displayed in Table 3a, b, and c, respectively.

Compared to the non-work context, the work context significantly enhanced the *accuracy* in the calculating subtest, in the overall test, as well as increased the overall *efficiency*—but only for participants with lower numerical intelligence. Higher numerical intelligence dampens this enhancing effect of the work context: participants with higher numerical intelligence performed as efficiently and accurately in the non-work context as in the work-context, or even better. These results indicate that participants with lower numerical intelligence benefitted more from the work context regarding their concentration.

Table 3
Linear model of predictors (Context, numerical intelligence (NI), Context × NI) of measures of the concentration task: *accuracy* in the calculating subtest, as well as *accuracy* and *efficiency* in the overall test.

	B (CI_l; CI_h)	*SE B*	β	t[a]	Sig. (p)
a. Calculating subtest: accuracy					
$R^2 = 0.30$, $p < 0.001$					
Constant	16.51 (13.42; 19.59)	1.54		10.74	$p = 0.000$
Context	−5.16 (−9.25; −1.07)	2.04	−0.73	−2.53	$p = 0.014$
NI	−0.11 (−0.19; 0.40)	0.15	0.12	0.72	$p = 0.472$
Context × NI	0.55 (0.15; 0.96)	0.20	0.83	2.75	$p = 0.008$
b. Overall test: accuracy					
$R^2 = 0.35$, $p < 0.001$					
Constant	28.74 (23.52; 33.96)	2.60		11.04	$p = 0.000$
Context	−10.52 (−17.45; −3.60)	3.46	−0.85	−3.05	$p = 0.004$
NI	0.23 (−0.27; 0.72)	0.25	0.15	0.92	$p = 0.361$
Context × NI	0.94 (0.26; 1.62)	0.34	0.80	2.75	$p = 0.008$
c. Overall test: efficiency					
$R^2 = 0.28$, $p < 0.001$					
Constant	0.66 (0.59; 0.73)	0.04		18.68	$p = 0.000$
Context	−0.16 (−0.25; −0.06)	0.05	−0.98	−3.33	$p = 0.002$
NI	0.00 (−0.01; 0.01)	0.00	−0.02	−0.09	$p = 0.928$
Context × NI	0.01 (0.00; 0.02)	0.01	0.89	2.93	$p = 0.005$

Note.
B = unstandardized beta coefficient, CI_l = lower confidence interval, CI_h = higher confidence interval, *SE B* = standard error, β = standardized beta coefficient, t = t-test statistic, p = significance value, R^2 = explained variation.
[a] Degrees of freedom: 57.

4. Discussion

4.1. Summary and conclusions

In recent years, work has become independent from traditional work spaces and become more and more ubiquitous due to developments in technology (Chen, Shechter, & Chaiken, 1996; Kurland & Bailey, 1999; Su & Mark, 2008; Sørensen & Gibson, 2004). Particularly little research has been done concerning the impact of ubiquitous work (in terms of working in a variety of different environments) on psychological variables related to productivity and work performance. However, it seems plausible that the surrounding context affects cognitive performance (e.g., Förster et al., 2005; Goclowska et al., 2014; Smith & Vela, 2001).

In a first step to examine these context effects, we compared cognitive performance in work and non-work context. We assumed that a work context holds associations with concepts of working and would activate a work-related schema. This schema might facilitate the accessibility of related cognitive resources and processes and could thus enhance performance.

In this study we addressed performance in activities that demand the same resources as typical knowledge work tasks normally do. We predicted that, compared to a non-work context, a work context would enhance *attention* (H1), *concentration* (H2), as well as risk taking in *decision making* (H3). Results from the measures of attention and concentration at least point in the assumed directions (some results were only marginally significant): a work context seems to more readily enhance performance in attention and concentration capability. In order to perform well in the LDT, participants have to pay attention to the task to quickly encode and compare the letter strings with words stored in their memory. Because people are assumed to associate work with, for example, time pressure, performing tasks well and asserting oneself, a work context might facilitate task completion and performance that is based on attention. In addition, participants in the work context were more accurate, faster and more efficient in some of the measures in the concentration test compared to participants in the non-work context. Speed increase in the concentration test was significantly greater in the non-work context compared to the work context. Participants in the work context might have taken the task more seriously and therefore worked more carefully and more precisely (and thus more slowly), compared to participants in the non-work context, because the work context might have activated associations of carefulness and efficiency (characteristics that are related to work activities and work-related tasks). In contrast, participants in the non-work context might have worked more inattentively and in a faster, but more sloppy and superficial manner. They might have had the goal of finishing the undesirable task that reminded them of work and that did not fit the non-work context, which implied acceptance of less efficient test processing. Results supported our Hypothesis 3 which states that a work context leads to riskier decision-making behaviour compared to a non-work context.

4.2. Implications for future research

As already mentioned in the introduction, various small components and physical features of environments such as light, temperature, climate, or sounds may have an impact on cognition and performance. To control for these confounding variables, we conducted the experiment in a lab situation and recreated the work and non-work contexts by means of virtual 3D-environments (office environment vs. Tuscany scenery). However, the lab situation and the restricted design of the virtual environments entail some other restrictions. For example, the usage of the two quite opposing environments (a blank interior space vs. a vivid outdoor area) might include effects we did not intend to elicit. The non-work environment did include more natural objects (e.g., grass, trees, and a river) than the work environment (that only included a potted plant). Research has already demonstrated that nature and natural views or natural materials have an impact on cognitive processes (e.g., McCoy & Evans, 2002; Tennessen & Cimprich, 1995). These potential confounding variables have to be kept in mind for future research.

Other limitations have to be considered, as the study took place in an artificial laboratory situation. All subjects participated in the same laboratory, a room in the institute that resembled an office. Participants in the non-work group might have experienced a conflict caused by the real setting they were in (in a laboratory room within a research institute) juxtaposed with the virtual setting they were asked to put themselves into (the virtual Tuscany scenery). This conflict might have weakened the priming effect of the environment. The artificiality of the lab situation and the fact that virtual environments are not real-world environments might have dampened the strength of the environmental impact in our study. However, as we found first effects even for virtual environments, one might expect even greater effects for real-world environments.

Within the parameters of this study we cannot specify which specific characteristics of certain contexts accounted for the reported effects. We also cannot be certain if the different contexts really activated the associations we intended (e.g., “being successful” and “working with full concentration” in the work context). The study was not designed in such a way that it would give us any precise insights into the internal processes that mediate the influence of context on cognition. However, the study has revealed effects of context in the behavioral data. We found that context affects work behaviour and work performance regarding *attention, concentration, decision making*, and also *speed* and *efficiency* of working. This indicates that the effect has quite a broad range of influence and is not focused on single aspects of working. To explain this wider impact of context, it is legitimate to assume that a given context activated a schema that, in turn, activated a comprehensive set of concepts, strategies, and cognitive actions that were either broadly or narrowly associated with work behaviour and work characteristics. The simultaneous activation of different associations through context might account for the impact on different aspects of work behaviour and work performance. It is also possible that processing styles, sets, and concepts associated with a certain context might differ individually due to learning effects or habits. Additional personal characteristics might also influence and mediate the context effect.

We found that the effect of the context on decision making was influenced by an interaction between the individual factors achievement motivation and freedom from constraints and the context. For example, higher achievement motivation strengthened the enhancing effect of the work context on risky decision making. In addition, the effect of the context on concentration was influenced by an interaction between the measure of numerical intelligence and the context. Context did not affect the concentration of participants with higher numerical intelligence, but participants with lower numerical intelligence did benefit from a work context. These results imply that internal factors might contribute to an external context effect.

There are a lot of personality traits and individual, internal factors that might be suspected influences. For example, Fischer, Tarquinio, and Vischer (2004) stated that a person's self-schema affects the perception of the physical work environment and therefore influences work performance in that work environment. In addition, feelings and emotions might mediate the effect of context on cognition and work behaviour. Steidle and Werth (2013) assumed that every environment and context is perceived subjectively and elicits certain feelings. Steidle and Werth assumed that dim light is associated with feelings of freedom and autonomy and therefore allows a more free and flexible cognitive processing style. To control for this mediator variable, we collected individual data for the feeling *freedom from constraints* and included it in the analysis. We found a significant interaction of freedom from constraints with the context on one measure of decision making, which indeed indicates a moderating role of freedom from constraints on the context effect. As we only controlled for this one feeling, we cannot reject the assumption that affect and other feelings we did not control for might influence context effects as well. A large body of research has already illustrated that affect is a strong mediator of various effects on, for example, cognitive processing styles or decision-making behaviour (Arkes et al., 1988; Baas, De Dreu, & Nijstad, 2008; Isen & Daubman, 1984; Isen & Patrick, 1983; Mittal & Ross, 1998). The impact of emotional factors should be kept in mind for future studies and should be controlled wisely.

Besides internal factors there are also external factors that might play an important role in explaining context effects on work performance. Some examples are organizational climate, employer traits, external restrictions, or degree of personal control over the work environment (e.g., for creative performance, Amabile, 1988; Oldham & Cummings, 1996; Tesluk, Farr, & Klein, 1997; Lee & Brand, 2005). These factors might also open up new research perspective in the field of context effects on work performance.

All in all, the list of variables that might contribute to the effect of context is quite long. A lot of internal or external factors are worth investigating and controlling for further studies. Basically, it seems plausible that there are individual differences concerning context effects on performance. For one example, people have different preferences for work environments in the first place. One person may favour working in a crowded park over working in an empty, silent office, preferring not to be alone but surrounded by people. Others, however, may absolutely not be able to concentrate when there is the slightest noise, or they cannot work in a moving environment such as a train or a car due to motion sickness. First results regarding a moderating role of numerical intelligence or achievement motivation on context effects indicate as well that individual differences should be considered. A next important step for research is therefore to identify individual contributing factors and investigate the interplay of external and internal factors to integrally understand how environment and context influences performance and cognition.

4.3. Implications for ubiquitous workers

In the introduction we posed some questions: if performance is not constant in different contexts, is ubiquitous working (thus working in changing environments) useful at all? Is it desirable or even possible to work successfully in a park or a café or should work be only conducted back in the traditional office? Or, in contrast, is it even beneficial to change environments and use different contexts intentionally to foster certain performance in certain tasks?

In view of the reported results, one might lean towards the following answer: regarding specific aspects of cognition (here: attention and concentration capability), working in a work context is beneficial compared to a non-work context. Accordingly, if performance enhancement is desired in tasks that need high attention and concentration, a knowledge worker should look for an environment that is related to a work context, such as a traditional office setting. An employer might want to take that into account when considering whether to delegate tasks that need high attention and concentration to employees that work remotely. Context has an impact on decision-making behaviour as well. Participants made riskier decisions in a work context than in compared to a non-work context. This knowledge should be handled thoughtfully. It indicates that decisions can be influenced by different contexts. This effect might be used intentionally to direct or shape people's decisions in certain ways. For example, if knowledge workers have to make fast decisions and save time, a work-context should be beneficial. However, if they have to make decisions for which they have to weigh the pros and cons in a very vigilant way (i.e., when great deliberation is needed), a non-work context might help in avoiding decisions which are too risky. It is important to make people aware that these effects exist and that the surrounding environment and context might influence the attention, concentration, and decision making of ubiquitous workers.

However, the question as to whether ubiquitous working is (not) useful at all cannot be answered finally with these results, although our findings suggest the superiority of the traditional work environment. The study presented here provides just a first glimpse into the answer. We investigated basic aspects of knowledge work behaviour in terms of attention and concentration capability as well as decision-making behaviour. However, knowledge work consists of many more factors, for example creativity, and flexible and divergent thinking styles. These aspects account for a large part of knowledge worker productivity and should be investigated in a next step. More unusual environments and contexts might be appropriate for fostering better performance in more unusual work tasks or activities, such as divergent processing styles and creativity.

Our results suggest in addition that employers should not send knowledge workers to non-work locations without having in mind that this might diminish the knowledge workers' performance. Instead, they might have to train their knowledge workers to actively *switch* their cognitive schemas from “leisure” to “work” if they have to or choose to work in non-work locations. For such personnel development training, virtual 3D environments – as the one we used for the manipulation in our study –might be well suited. For example, knowledge workers might be trained to solve specific work-related tasks in a leisure virtual environment. Before and subsequent to the performance phase, knowledge workers could be instructed to bring to mind the priming effects of environments we found, and to actively try to associate the leisure environment with work related features. In such a way, ubiquitous workers could be trained to demonstrate similar cognitive performance independently of being in a non-work or a work context.

To conclude, expanded research is needed to answer the question whether ubiquitous work (in terms of working in different environments) is useful or purposeful. Presumably, there is no one single yes-or-no-answer. It is likely that it depends on internal and external factors: performance might be enhanced when there is an optimum fit between the characteristics and demands of the task, a person with certain personality traits and preferences, and the surrounding environment. If further research is able to guide us to some of the answers, implications will be promising and of high practical use. The implications of this research affect the entire conception and organization of ubiquitous work forms. It might be possible for employers to intentionally select their working personnel according to certain internal factors that are suitable for ubiquitous work, or to relocate certain appropriate tasks completely to special environments in order to enhance performance. Ubiquitous workers might also intentionally be able to use context effects and change their working environment to enhance their own performance in context-fitting tasks.

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Appendix B - Submitted manuscripts

Office versus leisure environments: effects of surroundings on concentration

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Abstract

Mobile workers perform tasks that require high concentration not only in their traditional office but also within environments that are typically related to leisure (e.g., in a park or in the living room). Because research has shown that surroundings affect cognitive processing, we assume that concentration is different in office versus in leisure environments. We hypothesize that a typical office activates an associated (work-related) schema which in turn positively influences processes that are normally conducted within the environment (e.g., show high concentration in work-related activities in the office). In two studies, we assessed participants' objective and subjective work-related concentration twice, each time once within an office and once within a leisure environment. In study 1 (laboratory), we manipulated environments by means of virtual realities. In study 2 (field experiment), participants were tested within their self-elected, real-life environments. In both studies, results indicated higher work-related concentration when surrounded by an office compared to a leisure environment.

Keywords: Natural environments, workplace, mobile work, concentration, schema activation, cognition

1. Office versus leisure environments: effects of surroundings on concentration

Nowadays, work is no longer completed exclusively in the typical office but has also become mobile and may occur within changing environments (Bailey & Kurland, 2002; Chen & Nath, 2005; Hislop & Axtell, 2007; Moskaliuk, Burmeister, Landkammer, Renner, & Cress, 2017; Su & Mark, 2008; Vartiainen & Hyrkkänen, 2010). The evolution of modern information and communication technologies altered work practices completely in the last decades (e.g., Halford, 2005; Messenger & Gschwind, 2015). Many employees can work independently both in terms of time and space, because all they need can be found through mobile devices such as smartphones, tablets, or netbooks. Mobile work entails many benefits because it saves time and money. For example, employees save commuting time while employers save office spaces; mobile work offers autonomy and flexibility, and enables global cooperation (e.g., Demerouti, Ders, ten Bummelhuis, & Bakker, 2014; Hill, Ferris, & Märtinson, 2003; Hill, Miller, Weiner, & Colihan, 1998; Kurland & Bailey, 1999). However, mobile work also has some downsides. Employers have fewer possibilities to supervise or control their employees whereas employees might suffer from blurring boundaries between work and private life (e.g., Anderson & Rainie, 2008; Anderson & Rainie, 2014a, 2014b; Bailey & Kurland, 2002; Davis, 2002; Renner, 2014; Vartiainen & Hyrkkänen, 2010). Although mobile work is already common practice, it is still unclear in which way working within different environments affects cognition and work performance. Research regarding environmental effects on work performance often concentrates on typical work places (e.g., the office on company premises) to derive design recommendations to enhance performance, but it seldom investigates the effects of untypical, leisure-related environments (e.g., exterior areas such as gardens or private retreats such as the homely living room) although unfavorable surroundings also belong to the everyday working life of mobile workers. The studies presented here therefore investigate whether work-related cognitive performance differs within typical work-related (office) and typical leisure-related environments (garden scenery or at home). We combine the methods of a laboratory (study 1) and a field (study 2) experiment to ensure ecological validity. In study 1, we manipulate environments in the laboratory by means of virtual realities (a virtual office vs. a virtual garden) in a highly standardized and controlled manner. In study 2, we test participants either in their real office environment or in their self-elected leisure environment.

1.1 Cognitive performance and schema activation

Most mobile workers can be considered knowledge workers, whose work is mainly cognitive in nature (e.g., to collect, analyze, and evaluate information, to generate and use knowledge, to plan, or to decide) and requires concentration (Davis, 2002; Drucker, 1999; Ramirez & Nembhard, 2004). In the reported studies, we assess concentration in a work-related activity as an indicator of cognitive performance. To capture an integrative picture of concentration performance, we combine objective (a standardized work-related concentration test) and subjective measurements (ratings). Hill, Ferris, and Märtinson (2003) show that participants rated their own subjective performance higher while doing mobile work (not in the actual office) compared to work in the office but objective measurements did not support these subjective estimates. Hill et al. (2003) suggest that participants perceive the benefits of working mobile as being so valuable that it distorts participants' own evaluations of their actual performance. Therefore, the combination of objective and subjective measurements seems to be the appropriate strategy.

That the environment can affect cognitive performance seems to be generally accepted and in addition, a wide range of specific environmental elements have been identified that influence or shape cognitive processing (e.g., Slepian, Weisbuch, Rutchick, Newman, & Ambady, 2010; Smith & Vela, 2001; Vischer, 2008). These include, for example, windows (Aries, Veitch, & Newsham, 2010; Stone & Irvine, 1994; Tennessen & Cimprich, 1995), colors (Elliot, Maier, Moller, Friedman, & Meinhardt, 2007; McCoy & Evans, 2002; Mehta & Zhu, 2009; Stone, 2001; Stone & English, 1998), and light (Chellappa et al., 2011; Hygge & Knez, 2001; Lehrl et al., 2007; Steidle & Werth, 2013; Steidle, Werth, & Hanke, 2011). Therefore, it seems obvious to assume that mobile workers (i.e., those who work within different environments) do not show the same work-related concentration when surrounded by elements of a typical office (e.g., artificial light, solid wall colors, or practical office furniture) compared to elements of leisure environments (e.g., natural sun light and lush green plants in a garden or comfortable sofas in a cozy living room).

From a theoretical side, cognitive schema theories can help to explain potential differences in concentration within different environments. Cognitive schemas represent our knowledge about the world, elements, and stimuli (Fiske, 2000). Schemas are developed through learning and prior experiences and include expectancies, attitudes, rules and norms that help us to orient ourselves in the world and to choose adequate behaviors across different situations (Cohen & Ebbesen, 1979; Fiske, 2000; Fiske & Linville, 1980; Wirtz, 2013). Cognitive schemas organize knowledge into networks of information. They guide how new information is processed and can trigger related actions, and actions can in turn form new schemas (Fiske & Linville, 1980), for example in terms of behavior scripts (e.g., Abelson, 1976, 1981; Barsalou & Sewell, 1985).

Barsalou offers another approach by means of the situated concept theory (e.g., 1982). Barsalou states that concepts about entities in the world are not only collections of cognitive knowledge but are formed within and stored together with their background situations (1999, 2002, 2003; Yeh & Barsalou, 2006). This assumption is in line with the wide field of embodiment or grounded cognition research, which proposes that body, brain, and the environment interact to enable intelligent behavior (e.g., Barsalou, 2010; Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005; Prinz & Barsalou, 2000). In life, some situations are experienced repeatedly in combination with certain artefacts, people or actions and occur within certain environments. After some time, this knowledge becomes entrenched and supports the selection of adequate behavior as related associations come to mind automatically when situations arise (e.g., Barsalou, 2005, 2016; Yeh & Barsalou, 2006).

Relying on both approaches, we assume that people have learned throughout their working lives that they must show work-related behavior as soon as they are in an office environment. Speaking in terms of entrenched situated conceptualizations (e.g., Barsalou, 2005) people might have incorporated knowledge of and behavior in typical work situations in office environments. When being in the office they are expected to behave professionally, to not disturb others and to avoid distractions. The primary goal is to be productive, to show effort and to produce highly concentrated work. This situational knowledge is consolidated over time and activated by a typical office environment. In terms of cognitive schemas, people hold associations of work-related knowledge, activities, and behavior and typical work environments. Through prior experiences they have formed a ‘work-related schema’ including all expectancies, typical behavior, and attitudes towards work that can be activated by associated environments (e.g., typical work surroundings such as an office). In contrast, typical leisure environments (e.g., a park or a cozy living room) should activate a ‘leisure-related schema’ (e.g., show leisure behavior such as relaxing and going easy on cognitive resources) as people are used to avoiding strain and other unpleasant activities in leisure environments. Bridging both approaches results in the hypothesis that concentration is enhanced in office environments compared to leisure environments.

2. General method

2.1. Design and procedure

In two experiments, we varied the factor *environment* by means of a within-subjects design. We used the same design and measures in both experiments but assessed a different participant sample and varied the method of manipulation of environments. In each experiment, participants completed a concentration test and a subjective rating at two different times, once within a work-related environment and the other time within a leisure-related environment. A priori power analyses suggested a sample size of $N = 109$. Tests and instructions were presented in German. Data was recorded anonymously and participants signed informed consent statements beforehand. In both studies, participants received covered instructions that disguised the actual investigation purpose before starting the experiment ("the aim of this experiment is to investigate the impact of the work environment on mental states"). At the end of the study, participants were told the purpose of the study and assigned a generated personal code to guarantee anonymity.

2.2. Assessment of concentration

2.2.1. Objective work-related concentration

We assessed concentration by means of an adapted, shortened version of the *Psychomeda Konzentrationstest* (KONT-P; Satow, 2011). This standardized concentration task was adapted to typical requirements in work activities. The KONT-P measures performance in *calculating* (e.g., 1 + 2 + 1 + 2 + 2 =, solve simple equations) and *counting* subtests (e.g., 1 2 1 1 1 2 2 1 1 2 1 1, count the digit 1). For each subtest, we used 5 items (compared to 7 items in the original version of the KONT-P) consisting each of 7 equations (rows). Both subtests were presented in a randomized manner and participants had 20 seconds per item to solve as many equations as possible. Concentration was assessed in terms of *accuracy* (number of correctly solved equations), *speed* (number of equations solved at all), and *efficiency* (ratio between solved equations and correctly solved equations) for each subtest and for the overall test. A*ccuracy increase* (difference between accuracy in the first solved items and later solved ones) and *speed increase* (difference between speed in the first solved items and later solved ones) was calculated for the overall test. Higher scores indicate higher performance in concentration. We used two parallel versions of the KONT-P for the first and the second measurements (as offered by Satow, 2011).

2.2.2. Subjective concentration

In addition to the objective measurement of work-related concentration, we asked participants to rate how they subjectively perceived their own concentration capacity during the experiment. In study 1 and 2, participants rated satisfaction with their own performance on the concentration test using a 6 point Likert-scale: “How satisfied are you with your own performance in the test?” (Higher values indicate higher satisfaction). In study 2, we further specified subjective concentration by means of two additional questions: “How motivated do you feel right now?” and “How much do you feel you are concentrating right now?” (On a scale 1-6, with higher values indicating higher subjective motivation and higher subjective concentration).

2.3. Environment variables and demographic data

We checked whether manipulation of environments was successful by means of two questions: on a 5-point Likert scale, participants were asked 1) to rate how much they associate their current surrounding (virtual or real, respectively) with work and 2) how much they associate their current surrounding with leisure. Higher values indicated higher associations with work or leisure respectively. We considered a score < 3 on the relevant rating scale (i.e., a score of < 3 regarding association with work, within an office environment or a score of < 3 regarding association with leisure, within a leisure environment) as indicating unsuccessful manipulation and excluded participants in these cases from the analyses. In addition, we included several different, more specific measures regarding environmental manipulation for studies 1 and 2, because manipulation in the laboratory was implemented differently than manipulation in the field (see sections 3.1.3. and 4.1.3.). We assessed gender, age, and level of education as demographics.

2.4. Analyses

Differences in dependent variables between the first and second measurements were computed by means of paired t-tests for dependent samples. Environment was treated as a two-level within-subjects factor (office vs. leisure).

3. Study 1 - Laboratory

3.1. Method

3.1.1. Design

In study 1, we invited participants to the laboratory twice. To control for confounding effects of daytime, the study took place at the same time on two consecutive days. In a randomized manner, participants either explored the office environment or the leisure environment on the first day and, accordingly, the opposite environment on the second day. We recreated *office* and *leisure* environments by means of virtual realities (designed by the program Unity technologies ©), see Figure 1 (cf. Moskaliuk, Burmeister, Landkammer, Renner, & Cress, 2017). The office environment showed a typical office room, furnished with office equipment, such as a desk, a desk chair, a computer, or writing utensils. Participants were not able to leave the room but had a view from the window towards a busy street. The leisure environment showed lush green garden scenery with a view of mountains, a river, and a small cottage. Participants could look into the cottage, but not enter it.

Hypothesis 1a: Objective concentration (KONT-P) is higher after exploring the virtual office compared to the virtual leisure environment.

Hypothesis 1b: Subjective concentration (rating) is higher after exploring the virtual office compared to the virtual leisure environment.

Figure 1. Screenshots of virtual office (left) and virtual leisure environment (right).

3.1.2. Participants

N = 99 volunteers participated at the first time of measurement, *n* = 39 male and *n* =59 female (*n* = 1 not specified). Participants were between 18 and 65 years old (*M* = 26.18, *SD* = 8.77) and the majority were employed (63.6%). The education level of participants was high (1% Mittlere Reife (secondary school certificate), 3% Fachhochschulreife (advanced technical college certificate), 69.7% Abitur (advanced school-leaving certificate), 25.3% Hochschulabschluss (university degree). Volunteers were reimbursed with 8€ for participation. At the first measurement, *n* = 46 participants explored the virtual office environment and *n* = 53 participants explored the virtual leisure environment. *N* = 97 participants attended the second measurement (*n* = 49 work; *n* = 48 leisure). The sequence of the environments was randomly allocated. *N* = 90 complete datasets remained after exclusion of participants who yielded unsuccessful manipulation checks (see section 2.3.).

3.1.3. Additional measure

As suggested by Witmer and Singer (1998; see also Witmer, Jerome, & Singer, 2005), we assessed some characteristics of the handling and experience of the virtual realities with help of the *Presence Questionnaire* in order to make sure that both virtual environments were comparable. Higher scores indicate a higher immersion in the virtual reality (e.g., “my experience within the virtual environment complied with my experience within the real world”; approval rated on a 7 point Likert-scale).

3.1.4. Procedure and manipulation of the environment

Participants started the experiment with a 5-minute free exploration of the virtual environment receiving these instructions: “In the following, you can navigate freely through a virtual office/garden [respectively]. Please take a moment to walk and look around, explore your surroundings and immerse yourself in them. Imagine spending the next few hours in this place. What will you do there? How does it feel? Take 5 minutes. The experimenter will inform you when time has passed and the next test will continue. Use the arrow keys on the keyboard and the mouse to move”. After the free exploration, assessment of concentration (KONT-P, approx. 10-15 minutes), a rating of satisfaction with own performance, questions regarding associations with work or leisure, the presence questionnaire and demographics followed (approx. 10-15 minutes). The procedure was identical for the second day; except using the other virtual environment and with the addition of a debriefing at the end of the study. Six persons could participate simultaneously, separated by cubicles. The study ran on a laptop with a 15.3” screen. See Figure 2 for an overview of the procedure.

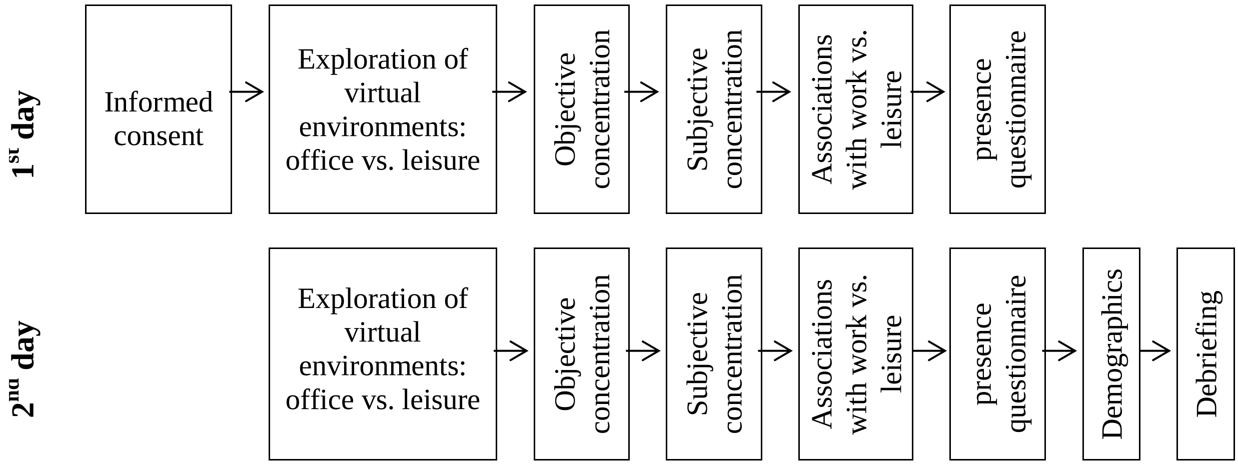

Figure 2. Flow chart of the procedure for first and second day assessments.

3.2. Results and discussion

3.2.1. Manipulation of environments

Manipulation of environments were considered successful under the following circumstances: in ratings of virtual office environment exploration, participants had higher associations with work (*M* = 4.93, *SD* = 2.03) than with leisure (*M* = 1.77, *SD* = .10), *t*(89) = 12.03, *p* < .001, Cohen's *d* = -2.20, and in ratings of the virtual leisure environment exploration, participants had higher associations with leisure (*M* = 5.97, *SD* = 1.59) than with work (*M* = 1.44, *SD* = .76), *t*(89) = -22.57, *p* < .001, Cohen's *d* = -3.64.

3.2.2. Differences in objective and subjective concentration between environments

In line with our hypotheses, we compared *objective concentration* (performance in the concentration test KONT-P) and *subjective concentration* (rating: satisfaction with own performance) between the conditions in which participants explored the virtual office vs. the virtual leisure environment at the beginning of the experiment. See Table 1 for t-test results and Table 2 for the mean values and standard deviations of all dependent variables.

Hypothesis 1a: We found differences regarding *efficiency* and *accuracy increase* in the KONT-P between environments that support our hypothesis (see Table 1). Participants who explored the office environment showed higher efficiency compared to participants who explored the leisure environment, Cohen's *d* = -0.21, as well as higher accuracy increase in the office environment compared to the leisure environment, Cohen's *d* = -0.26 (see Table 2). However, we did not find differences between office and leisure environments regarding *accuracy* and *speed* for calculating and counting, nor on the overall test or for *speed increase* on the overall test (see Table 1 and Table 2).

Hypothesis 1b: We did not find differences between office and leisure environments regarding the rating of *subjective concentration* (see Table 1 and Table 2).

Table 1

T-test results comparing differences in dependent variables between environments: Environment was treated as a two-level within-subjects factor (office vs. leisure).

	Paired differences			
Dependent variable	*M* (*SD*)	CI	t^a	*p*
Accuracy (calculating)	.21 (3.18)	[-.45, .88]	.63	.530
Accuracy (counting)	.47 (3.30)	[-.22; 1.16]	1.34	.183
Speed (calculating)	.14 (3.16)	[-.52; .81]	.43	.666
Speed (counting)	-.17 (2.60)	[-.71; .38]	-.61	.545
Accuracy (overall)	.68 (4.45)	[-.25; 1.61]	1.45	.152
Speed (overall)	-.07 (4.31)	[-.97; .84]	-.15	.884
Efficiency (overall)	.02 (.09)	[.01; .04]	2.17	.033*
Accuracy increase	.79 (3.73)	[.01; 1.57]	2.01	.048*
Speed increase	.12 (3.36)	[-.58; .83]	.35	.731
Subjective concentration	-.02 (1.14)	[-.26; .22]	-.19	.854

Note. *M* = mean, *SD* = standard deviation, CI = Confidence interval [lower; upper], *t* = t-test value, [a]degrees of freedom = 89, *p* = significance value, *significant at the *p* = .05 level.

Table 2

Mean values (M) and standard deviations (SD) of dependent variables in the work vs. leisure environment.

Dependent variable	*M* (*SD*)	
	Work	Leisure
Accuracy (calculating)	18.60 (5.22)	18.39 (4.23)
Accuracy (counting)	14.49 (4.23)	14.02 (4.26)
Speed (calculating)	20.29 (5.20)	20.14 (4.90)
Speed (counting)	17.57 (3.97)	17.73 (4.36)
Accuracy (overall)	33.09 (8.46)	32.41 (8.63)
Speed (overall)	37.81 (8.19)	37.88 (8.28)
Efficiency (overall)	.87 (.09)	.85 (.10)
Accuracy increase	4.64 (2.67)	3.86 (3.24)
Speed increase	6.80 (2.79)	6.68 (2.74)
Subjective concentration	3.66 (1.11)	3.68 (1.07)

Note. *N* = 90

3.2.3. Sequence effects: 2 x 2 mixed factorial ANOVA

About half of the participants explored the office environment during the first measurement (and the leisure environment at the second measurement) whereas the reverse was true for the other half of participants. Although we did use parallel versions of the KONT-P for the repeated measurements in the office and the leisure environment, participants might have benefitted from a training effect at the second measurement. Further analyses investigate this assumption using 2 x 2 mixed factorial ANOVAS: office vs. leisure environment (varied *within subjects*) x office environment on first measurement vs. office environment on second measurement (varied *between subjects*). We found one significant interaction for *accuracy* on the counting part, $F(1, 88) = 4.24$, $p = .051$, partial $\eta^2 = .04$, all other $p > .066$. Performance was higher when the office environment was explored in the second measurement but not, when office environment was explored in the first measurement. This suggests an order effect: the benefit of training might have added to the general effect of the office environment. Because the manipulation of the environment (i.e., the allocation of participants to the office or leisure environment) was randomized, sequence effects should be balanced. However, a potential training effect should be kept in mind.

4. Study 2 - Field

4.1. Method

4.1.1. Design

In study 2, we assessed concentration performance in an *office* vs. a *leisure environment* through a field experiment. We asked participants to complete the same online experiment twice (on two consecutive days), once within their typical office environment and once within their typical leisure environment. Since participants in study 1 might evaluate differently whether an environment is typically related to work or to leisure, in study 2 we asked participants to choose their own surrounding – either their regular office or a place where they usually perform leisure activities. Several control variables were assessed to check for successful manipulation. Employed persons were exclusively invited through a mailing list and social media and then registered themselves via a survey. Compared to study 1, we added two questionnaires to further specify subjective concentration by assessing subjective motivation and concentration rating, in addition to satisfaction with one's own performance. We also added two questions to assess whether office environments did in fact activate work-related schemas and whether leisure environments activated leisure-related schemas (see section 4.1.3.).

Hypothesis 2a: Objective concentration (KONT-P) is higher within the office environment compared to the leisure environment.

Hypothesis 2b: Subjective concentration (rating) is higher within the office environment compared to the leisure environment.

Hypothesis 2c: Activation of a work-related schema is higher within the office environment compared to the leisure environment and likewise, activation of a leisure-related schema is higher within the leisure environment compared to the office environment.

4.1.2. Participants

N = 103 participants registered to participate in the study, n = 48 male and n = 56 female (n = 2 not specified). Participants were between 21 and 54 years old (M = 32.37, SD = 8.67). Education level of participants was high (1,9% Mittlere Reife (secondary school certificate), 4,7 % Abitur (advanced school-leaving certificate), 23,6% Berufsausbildung (completed vocational training), 66% Hochschulstudium (university degree), 3,8% not specified). All participants were employed (current employment was inclusion criteria, students were not invited). After registration, N = 97 completed the first and the second experiments (46 male, 50 female, 1 not specified; M_{age} = 32.67, SD_{age} = 8.75). Of these participants, N = 91 participants (46 female, 43 male, 2 not specified; M_{age} = 32.41, SD_{age} = 8.83), also followed instructions (i.e., opened the link in compliance with the environment as assigned in the instruction e-mail). On the first day, n = 44 participants completed the experiment in the office environment, n = 47 in the leisure environment and vice versa on the second day. Participants were compensated with the chance to win two 25€ vouchers.

4.1.3. Additional measures

Since it is difficult to control for disturbances in a field experiment within real-life environments, we included several questions regarding characteristics of the environment or environmental disturbances. The experiment began with four *environment salience questions* that served two purposes: first, these questions provided an impression of where participants completed the experiment and whether they followed the instructions to complete it in the assigned environment (in terms of a manipulation check). Second, these questions functioned as a tool to make the environment more salient to the participant. In answering these specific questions, participants were forced to look around and explore their environment (in terms of strengthening the manipulation). Questions were asked in open response format and participants typed their answers in an empty field. Examples were provided in brackets for facilitation.

1. Where are you? (For example: outdoors in nature or indoors in a closed room / in the garden or office at work / sitting on the couch or sitting on desk chair).
2. What do you see, hear and smell? (For example: kind of furniture, plants, people or technical devices in vicinity / perceived sounds or odors / familiar or unfamiliar visual and auditory stimuli).
3. What is the atmosphere of your surroundings? (For example: relaxed / quiet / well-rested / secure or tense / strained / hectic / nervous / pressured).
4. Do you have any other comments about your environment?

At the end of the experiment, participants were asked to rate subjectively perceived *distraction* on a 6 point Likert-scale ("how much did you feel distracted during the experiment by visual or auditory stimuli in your environment?"; higher values indicate higher distraction) to ensure that both environments were comparably distracting.

Furthermore, we added two questions regarding the activation of schemas: *work-related schema* ("are you currently in a work mode?") and *leisure-related schema* ("are you currently in a leisure mode?"). We asked participants for *mode* instead of *schema*, as mode is a more familiar term (the phrase "im Arbeitsmodus/Freizeitmodus sein", "being in a work mode/leisure mode" is a common expression in German language). Participants were asked to rate their agreement on a 6-point Likert scale (higher values indicate higher agreement).

4.1.4. Procedure and manipulation of the environment

Volunteers registered by filling in a demographics survey (approx. 2 minutes). Afterwards participants were asked to enter an e-mail address, where they wished to receive the instructions for both measurements (the e-mail address was saved separately to guarantee data security). The first and second experiments took place on two consecutive working days (between Monday and Friday). On each day, participants received a link via e-mail leading to the experiment with the instruction either to open the link in their office or their leisure environment (e.g., instruction for the *office* condition: "the online questionnaire must be completed at your workplace. Please select your typical workplace. Please keep in mind that you need internet access to complete the questionnaire. Examples of working environments include your office at your employer, a public workroom or your private workroom."). Participants were assigned their environment (office or leisure) for the first day of testing in randomized manner. After participants arrived at the indicated environment, they were allowed to click on the link in the e-mail leading to the online experiment. Assessment started with the four open questions regarding environment salience followed by questions regarding associations with work or leisure (approx. 5 minutes), assessment of objective concentration (KONT-P, approx. 10-15 minutes), and subjective concentration (ratings), ratings of activation of work-related or leisure-related schema and distractions (approx. 5-10 minutes). Procedure and content of both days of measurement were identical except the instruction where to open the link and a debriefing after finishing the experiment on the second day. See Figure 3 for an overview of procedure.

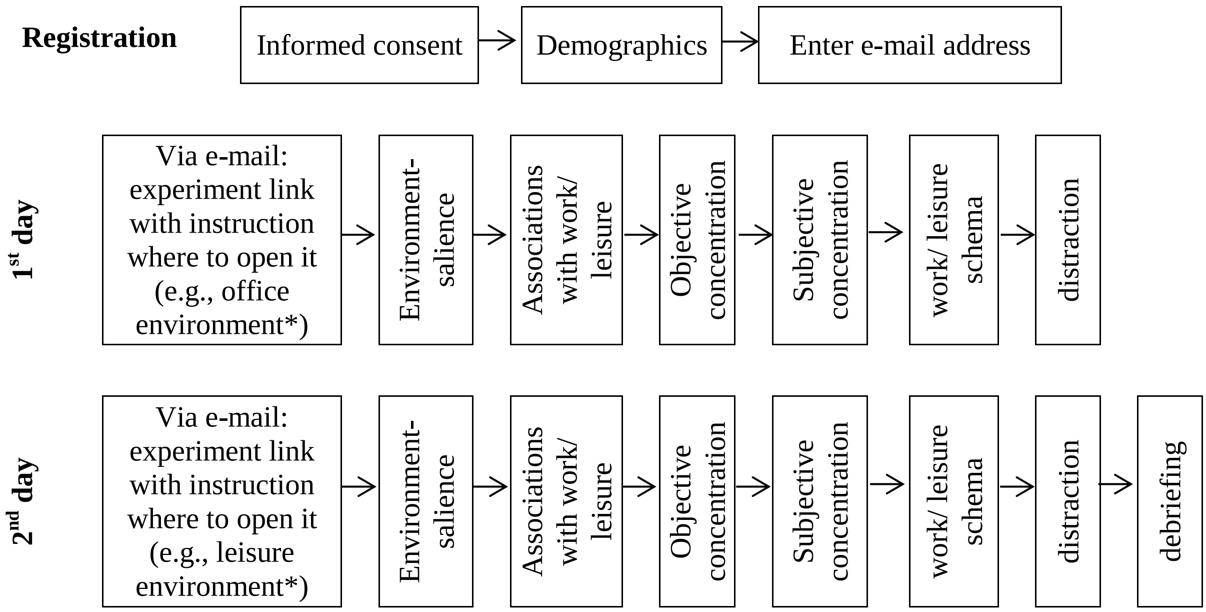

*Figure 3.*Flow chart of the procedure for registration, first day, and second day assessments.

* Randomized allocation of environments

4.2. Results and discussion

4.2.1. Environment selection

Allocation of environments can be considered successful in the following circumstances: When participants received instructions to complete the experiment in their office environment, they rated their associations higher for work (M = 4.59, SD = .63) than for leisure (M = 1.42, SD = .54), $t(90)$ = 30.10, p < .001, Cohen's d = -4.40. When participants received the instruction to complete the experiment in their leisure environment, they rated their associations higher for leisure (M = 4.51, SD = .79) than for work (M = 1.64, SD = .75), $t(90)$ = - 21.02, p < .001, Cohen's d = -3.73. In addition, three evaluators rated the *environment salience questions* manually. Participants were excluded from the analyses if answers to these questions indicated a violation of instructions (e.g., answering the question "where are you?" with "at home in the living room" in both environment conditions or with “at the desk in my corporate office” in the leisure environment condition). This resulted in the exclusion of $n = 6$ participants. We assessed perceived *distraction* within both environments and did not find a difference in distraction ($p = .371$) between office or leisure environments.

4.2.2. Differences in objective and subjective concentration between environments

In line with our hypotheses, we compared *objective concentration* (performance on the concentration test KONT-P) and *subjective concentration* (ratings: satisfaction with own performance, subjective concentration, subjective motivation) between the conditions in which participants completed the required tasks in an office vs. a leisure environment. See Table 3 for t-test results and Table 4 for the mean values and standard deviations of all dependent variables.

Hypothesis 2a: We found differences regarding *accuracy* and *speed* for the calculating subtest as well as for the overall test, which supports our hypothesis (See Table 3). Participants in the office environment showed higher *accuracy* on the calculating subtest of the KONT-P, compared to participants in the leisure environment, Cohen’s $d = -0.15$, and higher *accuracy* in the overall test, Cohen’s $d = -0.16$ (see Table 4). Differences regarding *speed* did not reach significance on the $\alpha = .05$ level but the effects trended in the same direction: higher *speed* on the overall test in the office environment compared to the leisure environment, Cohen’s $d = -0.16$. The same holds true for *speed* in the calculating subtest, Cohen’s d = -0.13 (see Table 3 and Table 4). We did not find differences between office and leisure environments regarding *accuracy* or *speed* for the counting subtest, nor regarding *efficiency, accuracy increase* and *speed increase* on the overall test (see Table 3 and Table 4).

Hypothesis 2b: We found two differences for subjective concentration between office and leisure environments that support the hypothesis (see Table 3). Participants in the office environment indicated higher *subjective concentration*, Cohen’s $d = -0.16$, and higher *subjective motivation,* Cohen’s $d = -0.32$, compared to participants in the leisure environment (see Table 4). We did not find differences between office and leisure environments regarding *satisfaction with own performance* (see Table 3 and Table 4).

Table 3

T-test results comparing differences in dependent variables between environments: Environment was treated as a two-level within-subjects factor (office vs. leisure).

Dependent variable	Paired differences M (SD)	CI	t^{a}	p
Accuracy (calculating)	.67 (3.00)	[.05; 1.30]	2.13	.036*
Accuracy (counting)	.48 (3.85)	[-.32; 1.29]	1.20	.235
Speed (calculating)	.56 (2.99)	[-.06; 1.18]	1.79	.077
Speed (counting)	.49 (3.48)	[-.23; 1.22]	1.35	.179
Accuracy (overall)	1.15 (5.42)	[.02; 2.28]	2.03	.045*
Speed (overall)	1.08 (5.23)	[-.01; 2.17]	1.96	.053
Efficiency (overall)	.01 (.09)	[-.02; .02]	.47	.643
Accuracy increase	.12 (3.50)	[-.61; .85]	.33	.743
Speed increase	-.02 (3.29)	[-.71; .66]	-.06	.949
Subjective concentration	.42 (1.61)	[.17; .08]	2.48	.015*
Subjective motivation	.36 (1.39)	[.08; .65]	2.50	.014*
Satisfaction with own performance	.18 (1.41)	[-.12; .47]	1.19	.238
Work-related schema	2.18 (1.70)	[1.82; 2.53]	12.23	.001*
Leisure-related schema	-2.32 (1.65)	[-2.66; -1.98]	-13.44	.001*

Note. M = mean, SD = standard deviation, CI = Confidence interval [lower; upper], t = t-test value, [a]degrees of freedom = 90, p = significance value, *significant at the p = .05 level.

Table 4

Mean values (M) and standard deviations (SD) of dependent variables in the work vs. leisure environment.

Dependent variable	M (SD) Work	Leisure
Accuracy (calculating)	19.09 (4.21)	18.42 (4.36)
Accuracy (counting)	13.24 (3.88)	12.76 (3.73)
Speed (calculating)	20.31 (4.21)	19.75 (4.30)
Speed (counting)	15.67 (3.43)	15.18 (3.13)
Accuracy (overall)	32.33 (7.10)	31.18 (7.19)
Speed (overall)	36.00 (6.57)	34.92 (6.76)
Efficiency (overall)	.89 (.08)	.89 (.09)
Accuracy increase	4.20 (3.17)	4.08 (2.73)
Speed increase	5.60 (2.80)	5.63 (2.66)
Subjective concentration	4.23 (1.16)	3.81 (1.22)
Subjective motivation	4.57 (1.09)	4.21 (1.17)
Satisfaction with own performance	3.73 (1.01)	3.55 (1.21)
Work-related schema	4.57 (1.28)	2.40 (1.41)
Leisure-related schema	1.88 (.95)	4.20 (1.42)

Note. N = 91

4.2.3. Schema activation

Hypothesis 2c: We found differences regarding *work-related* and *leisure-related schemas* that are in line with the hypothesis and indicate successful activation of desired mental schemas (see Table 3). Participants in the office environment indicated a more pronounced *work-*

related schema compared to participants in the leisure environment, Cohen's d = -1.61. The reverse was also true: participants in the leisure environment indicated a more pronounced *leisure-related schema* compared to when they were in the office environment, Cohen's d = -1.93 (see Table 4).

4.2.4. Sequence effects: 2 x 2 mixed factorial ANCOVA

To investigate potential training effects, we used 2 x 2 mixed factorial ANOVAS (office vs. leisure environment [*within*] x office environment on first measurement vs. office environment on second measurement [*between*]).

We found significant interactions of environment and sequence (i.e., office environment on first vs. on second measurement) for *subjective concentration*, $F(1, 89) = 5.40$, $p = .022$, partial $\eta^2 = .06$; *satisfaction with performance*, $F(1, 89) = 8.40$, $p = .005$, partial $\eta^2 = .09$; *accuracy* in the counting part, $F(1, 89) = 8.80$, $p = .004$, partial $\eta^2 = .09$; and in the overall test, $F(1, 89) = 8.08$, $p = .006$, partial $\eta^2 = .08$; as well as *speed* in the counting part, $F(1, 89) = 8.59$, $p = .004$, partial $\eta^2 = .09$; and the overall test, $F(1,89) = 7.60$, $p = .007$, partial $\eta^2 = .08$. All other $p > .149$. Like study 1, results suggested an effect of order: performance was higher in the office environment when it was presented at the second time point but not when it was presented at the first time point, which indicates that the benefit of the training effect at the second measurement might have added to a general effect of the office environment.

5. Summary and concluding discussion

Across two studies, we investigated whether environments influence work-related cognitive performance in terms of objective concentration as well as subjective assessments of concentration. We assumed that a typical office environment activates an associated (work-related) schema which in turn positively affects processes that are normally conducted within the environment (e.g., greater concentration in work-related activities the office). At the same time, we assumed that a typical leisure environment activates a leisure-related schema that should not have a favorable effect on concentration in work-related activities. Through a lab experiment (study 1) and a field experiment (study 2), we found several results that support our hypotheses. In study 1, participants showed higher efficiency and higher accuracy increase in the office environment condition compared to the leisure environment condition. In study 2, participants showed higher accuracy and speed in the office environment compared to the leisure environment, as well as higher subjective concentration and subjective motivation. In addition, participants rated a higher activation of a work-related schema when being in the office environment compared to the leisure environment and a higher activation of a leisure-related schema when being in the leisure environment compared to the office environment.

5.1. Schema activation

Results support the assumption that the manipulated environments activated the related schemas (i.e., office environments activated work-related schemas whereas leisure environments activated leisure-related schemas). In both experiments, we asked participants to rate their associations of the environments either with work or with leisure and found significant effects in the expected direction. Office environments elicited higher associations with work than with leisure and, conversely, leisure environments elicited higher associations with leisure than with work. In study 2, we asked participants additionally to indicate whether they felt like they were in ‘work mode’ or a ‘leisure mode’. Results again emerged in the assumed direction: participants indicated a higher work mode (i.e., higher activation of a work-related schema) when they were surrounded by a typical office and a higher leisure mode (i.e., higher activation of a leisure-related schema) when they were surrounded by leisure environments. However, as the activation of associated schemas is a mental process, it is impossible to directly monitor or assess it and we can only rely on subjective measurements or measure related processes (Fiske & Linville, 1980). Further research is needed to investigate the underlying process of mental schema activation.

5.2. Individual differences in personality and experience

It is reasonable to assume that not every person is affected in the same way by external pressures such as the environment. Some people may be more capable of completing mobile work than others. For example, many people cannot work in a congested train whereas others do not seem to be distracted at all. A lot of personality variables might be responsible for these differences, for example conscientiousness or action orientation (Hossiep & Paschen, 2003). More conscientious people with higher action orientation might be more able to activate an appropriate work-related schema (also when not in a typical work environment such as an office) to orient themselves toward the goal of working efficiently while also preventing themselves from being distracted. As another example, individual differences in current mood states might affect the relationship between environment and performance (e.g., Gasper, 2003; Isen, 1999; Isen, Daubman, & Nowicki, 1987; Olivers & Nieuwenhuis, 2006).

Therefore, it is necessary for future research to investigate what makes a successful mobile worker and how they succeed in activating an adequate cognitive work-related schema that allows them to work efficiently, independently of the physical environment.

In addition, we assume that another important factor is individual learning experience. We found significant interactions of the environment and sequence (i.e., whether the participants completed the experiment in the office environment at the first or second time of assessments), which raise this concern. Participants seemed to be less affected by the positive influence of the office environment when they already completed the experiment in the leisure environment at the first time; the training effect might have dampened potential effects of the environment. Compared to other forms of work, mobile work is a recent development. Although in 2016, 61% of German employers enabled their employees to work remotely by means of providing appropriate devices and mobile internet access, mobile work has not yet arrived everywhere (Statistisches Bundesamt, 2016). However, regarding modern developments and digitalization, mobile and flexible working conditions will soon be firmly established in the majorities' occupational routine. When working in multiple environments becomes commonplace and workers acclimate to it, performance differences between environments might converge and disappear with sufficient experience.

5.3. Assessment of concentration performance

We assessed concentration capacity as it is one important prerequisite of actual work performance. However, concentration does not reflect an ordinary work activity but is instead an integral part of many work tasks. Future research must investigate other performance measures and different work activities (e.g., Moskaliuk et al., 2017). For example, it seems plausible that experienced mobile workers adapt their work tasks to their current environment and would not choose a task that needs high concentration (such as calculating or counting accurately under time pressure) while in unsuitable surroundings. Future research should investigate real life strategies of successful mobile workers to cope with different environments as surroundings might differently affect various tasks. For example, untypical environments (such as a leisure environment) might enhance performance in creative tasks (e.g., Dul & Ceylan, 2011; Dul, Ceylan, & Jaspers, 2011). Nonetheless, there are likely many instances in which mobile workers are required to prepare a task in an environment that is not optimal.

In addition, it is very interesting to note that we found effects for objective concentration measures in both studies, but not for all subjective ratings. As Hill et al. (2003) suggested, participants seem to subjectively perceive their own performance differently from objective performance measures when it comes to mobile work. Participants themselves do not report being affected by different environments although objective measures suggest otherwise. In both studies, participants did not differ in their rating of satisfaction with own concentration performance between environments although we found objective differences. This raises the concern of whether mobile workers can rationally evaluate their own performance when working from home or from other places apart from the typical office. This is an important notion for employers who consider giving their employees the opportunity to work remotely and must consider how to monitor their employees' performance.

5.4. Methodological limitations

Although several results in both studies underpin our hypotheses, the effects are small, which might be mainly due to several methodological limitations. First, the manipulation of office and leisure environments may have influenced effect size. Although manipulation checks in both studies revealed successful manipulation of environments, both methods of manipulation (in the laboratory and the field) show some weaknesses. In the laboratory (study 1), we recreated an office and a garden by means of virtual reality. Although every participant explored the same virtual environment, these environments might not reflect a typical office or leisure surrounding for each person. In such cases, the association between the displayed environments (office and garden) and the intended schema might not have been strong enough to activate related behaviors (e.g., enhanced concentration through elicited work-related schema). Most people might associate a typical work environment with an indoor room (office) including a desk, chair, storage cupboards, technologies (e.g., computer, printer, or a telephone), work utensils and documents. Compared to that, typical leisure environments seem to be more individual. For some, a leisure environment might be a cozy living room with furniture made of soft textiles, stimulating decoration (e.g., photographs, art, plants, or flowers), consumer electronics (e.g., TV, game consoles, music systems); for others, it might be an outdoor environment such as a garden with birds' twittering, trees, plants, the blue sky and fresh air. Another weakness of manipulating the environment by means of virtual reality might have been the artificial laboratory setting. Participants came to the lab, which resembles more of an office environment than a leisure environment because it is a room with desks, laptop computers, office chairs, and work utensils. The actual physical environment (the lab) and the virtual environment (office or garden) might have been in conflict, which might have dampened the effects. Keeping these flaws in mind, we conducted the second study using a more ecologically valid field experiment design. However, field experiments are accompanied by other weaknesses, such as a lack of controllability. By asking several questions regarding the current physical environment (e.g., What do you see? What do you hear?), we aimed to control whether participants honestly followed the instructions to conduct the experiment only within the defined environment but we cannot objectively verify participants' statements. In addition, it is impossible to control for the various potentially confounding factors within real environments, such as noise or sounds, temperature, light and other people. Since we are aware of the advantages and disadvantages of both methods (laboratory and field), we combined them to gain a broad insight.

Another detriment of study 1 might have been the composition of the participant sample, because not all participants were currently employed (36.4% of participants indicated that they are not currently employed). It might be assumed that a considerable proportion of participants were students who might have had different experiences with completing tasks that require high concentration. This assumption is, for example, also supported by the low average age (M = 26.18), which suggests less work experience compared to people of an older age. In the introduction, we argued that the association between work-related schemas and typical work environments such as an office is established through prior experiences and a continuous and repeated learning process. Nonworkers and students or inexperienced job entrants might not have developed the necessary association strength of work-related schemas and office environments. Therefore, for study 2, we excluded students from the participant sample and only invited working and currently employed participants.

We could address several limitations of the first study in the second study (e.g., sample composition as well as real and individually typical environments), which revealed a different detriment in return: potential daytime effects. In the field experiment (study 2), we asked participants to conduct the experiment once in their office and once in their leisure environment. To control for effects of workdays and weekends, participants were asked to conduct the experiment only from Monday to Friday. As a result, most participants conducted the experiment during work hours (morning to afternoon) when they were asked to open the link within their office environment and after work (evening) when they were asked to open the link within their leisure environments. We have to keep in mind that effects of daytime could have confounded results as cognitive performance has been shown to vary throughout the day (e.g., Carrier & Monk, 2000; Schmidt, Collette, Cajochen, & Peigneux, 2007; Van

Dongen & Dinges, 2000). However, in study 1 we did control for daytime effects by inviting participants to the laboratory at the same time of day on two consecutive days.

5.5. Comparability of leisure environments

Using an explorative approach, we had a closer look at the open questions in study 2 (field study) to gain insight into the leisure environments that participants chose. Results revealed that, except one person, all other participants chose their home as a leisure environment. Therefore, the comparison between leisure environments in study 1 and study 2 is limited. However, this allows us to compare office environments with two different types of leisure environments: outdoor environments and familiar home surroundings. For study 1 (virtual garden scenery as a leisure environment), it could be argued that the results might be explained by natural restoration effects. Research has shown that natural environments can enhance cognitive performance as nature views have the potential to restore attention (e.g., Berman, Jonides, & Kaplan, 2008; R. Kaplan, 1993; S. Kaplan, 1995; Korpela, Bloom, & Kinnunen, 2014; Largo-Wight, Chen, Dodd, & Weiler, 2011; Richardson et al., 2016). However, we found similar effects in study 2, wherein participants predominantly chose an indoor home surrounding as their leisure environment. Therefore, the larger role of natural restorative effects seems unlikely.

Besides the difference in natural elements of the leisure environments in study 1 and study 2, there is also a difference in familiarity. Participants in study 2 mainly chose habitual, familiar surroundings as leisure environments which might have caused different effects compared to new, unusual surroundings. Familiar surroundings might lose their distracting properties after some time and participants might have learned to complete highly concentrated tasks at home, for example reading a book (either for work or for leisure), learning for an exam, or doing mathematical calculations for the annual tax declaration. Environmental effects on cognitive performance might have dampened due to habituation. Future research should further refine the selection of leisure environments and control for familiarity to compare performance differences between environments. For example, for future field studies participants might be impelled to choose a leisure environment outside of their homes where they have not conducted work-similar effortful tasks before (e.g., an unfamiliar park or an unfamiliar tea room, respectively).

Across two related studies, we found results suggesting a superiority of office environments (compared to leisure environments) when performing tasks that require high work-related concentration. Future research should investigate environmental effects on performance in other tasks and activities since the picture could look different, for example for tasks that require high creativity. In addition, research should investigate the assumption of whether individuals are able to habituate to different environments and to activate appropriate work-related schemas independently from physical surroundings.

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Does priming a work versus a leisure concept affect concentration performance?

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Abstract

Previous research found that activated concepts influence information processing and have the potential to affect behavior. We assumed that a *work concept* activates work-related behavior (i.e. working with good concentration; being in a "work mode"), whereas an activated *leisure concept* leads to leisure-related behavior (i.e. relaxing; being in a "leisure mode"). In one field and one laboratory experiment, we primed participants either with a work or a leisure concept and assessed objective and subjective concentration, and self-reported activation of work and leisure mode. Results did not reveal significant differences between priming conditions but higher activiation of work mode was related to higher subjective and objective concentration performance.

Keywords: Concept activation; cognitive priming; concentration; work mode

1. Does priming a work versus a leisure concept affect concentration performance?

Individuals form cognitive schemas (Fiske, 2000; Fiske & Linville, 1980) or concepts (e.g., Barsalou, 1982) about elements, experiences, and stimuli as a way to structure their knowledge and to orient in the world. A concept is an individual, mental representation of an entity, including all available information and knowledge about its attributes, relations, or occurrence. Various stimuli are suspected to activate related concepts, for examples, material objects (e.g., Kay, Wheeler, Bargh, & Ross, 2004), stereotypes (e.g., Förster, Friedman, Butterbach, & Sassenberg, 2005), or environments (e.g., Moskaliuk, Burmeister, Landkammer, Renner, & Cress, 2017). A concept is formed in the course of prior learning experiences and guides how new information is processed or which behavioral responses are selected (Fiske, 2000; Fiske & Linville, 1980). We assume that individuals have also formed concepts about *work* including knowledge about prior experiences with workplaces, colleagues, or work-related activities. Because concepts have been found to affect cognitive processing, we assume that a work concept also affects working with great concentration, a behavior that is expected in work situations. Through one field experiment and one laboratory experiment, we take a first step to examine effects of activated work or leisure concepts on concentration.

We used a priming method to activate concepts and to examine their potential effects. Bargh and Chartrand (2000, p.3) describe priming as the "preparedness of mental representations to serve a response function". Does an active work concept enable a behavioral response conducive to good performance in work-related activities (i.e., yield good concentration)? Conceptual priming methods use manipulations to unconsciously activate a mental representation, in order to be able to investigate its influence on a subsequent unrelated task (Bargh & Chartrand, 2000). For example, stereotypes, goals, emotions, or social norms have been shown to affect cognitive processing and behavior when being activated by priming (e.g., Bargh, 2006). In the experiments reported here, our objective was to activate a *work* vs. a *leisure* concept through *work*-related vs. *leisure*-related words in a scrambled sentence test, a frequently used priming method (e.g., Bargh, Chen, & Burrows, 1996). We assumed that an activated work concept should activate work-related behavior, such as working with good concentration (i.e. being in a "work mode"), whereas an activated leisure concept should activate leisure-related behavior, like avoiding cognitive effort and relaxing (i.e. being in a "leisure mode"). Thus participants who were primed with work words would report a higher work mode and show greater concentration compared to participants who were primed with leisure words. We assessed activation of *work* and *leisure mode* by self-reports and concentration by means of an *objective* standardized concentration test and a *subjective* self-report rating.

Hypotheses: Participants will report being in more of a *work mode,* compared to a leisure mode, after completing a scrambled sentence test with *work*-related words (and reversely, more of a *leisure mode,* compared to a work mode, with *leisure*-related words; *H1*). *Objective concentration* (*H2*) and *subjective concentration* (*H3*) will be higher in conditions in which participants were primed with *work*-related compared to *leisure*-related words.

2. Method

2.1 Design

We conducted a field experiment and then replicated it with the same design, procedure, and materials in the laboratory. In a one factor-between-subjects-design, we intended to activate either a *work* or a *leisure* concept; dependent variables were *objective* and *subjective concentration* and reported activation of *work* and *leisure mode*. Data was assessed in an anonymous online survey and both studies complied with the ethical standards of the American Psychological Association. Tasks and instructions were written in German.

2.2 Participants

Seventy-three volunteers participated in the field experiment, 11 had to be excluded due to incomplete task processing. $N = 62$ participants remained, of which 32 were randomly assigned to the *work* and 30 to the *leisure* conditions. 94 volunteers participated in the laboratory experiment, 8 were excluded due to incomplete task processing ($N = 86$, $n = 53$ *work*, $n = 33$ *leisure*). See Table 1 for demographics.

Table 1

Demographics (age and gender) of participants in the field and laboratory experiments.

Experiment	*N*	Age *M* (*SD*), [Min - Max]	Gender
Field	73	27.71 (6.60), [19 - 55]	48 female, 14 male, 11 not reported
Laboratory	94	23.14 (4.83), [18 - 60]	73 female, 18 male, 3 not reported

2.3 Procedure

Participants were invited via a mailing list. In the field experiment, participants started wherever they were by clicking on a survey link which forwarded them randomly either to the *work* or *leisure* condition. The cover story introduced the goal of measuring language ability and numerical aptitudes with a simple German and Math test. Participants started with the illusory language test (scrambled sentence test) that contained either work- or leisure-related words. In actual fact, the test was intended to activate either a *work* or a *leisure* concept. Participants continued with the illusory numerical aptitude test, which was actually a standardized concentration test measuring *objective concentration*. The testing was followed by self-reporting which rated *subjective concentration*, activated *work* and *leisure mode*, demographics (age, gender) and debriefing (see Figure 1). The procedure in the laboratory experiment was identical, but participants completed it exclusively in the laboratory to control the environment.

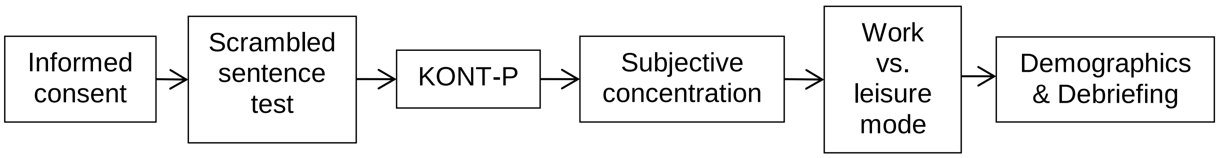

Figure 1. Flow chart of procedure in the field and laboratory experiment

2.4 Material

2.4.1 Scrambled sentence test

The scrambled sentence test (Bargh et al., 1996; Doyen, Klein, Pichon, & Cleeremans, 2012) was adapted to activate either a *work* or a *leisure* concept. The test consisted of 30 scrambled sentences. For each sentence participants were asked to select those four words out of five that made a meaningful sentence. To cover up the actual goal, fifteen sentences containing neutral words were presented intermixed with the fifteen sentences that contained either work-related or leisure-related words (see Figure 2). All words were pretested to ensure equality in length and valence.

Words	Scrambled sentence test					Right answer
Work-related	☐ moon	☑ her	☑ She	☑ colleagues	☑ likes	She likes her colleagues
Leisure-related	☑ a	☑ little	☐ yellow	☑ Take	☑ trip	Take a little trip
Neutral	☐ fur	☑ is	☑ The	☑ round	☑ earth	The earth is round

Figure 2. Examples of the scrambled sentence test with work-related, leisure-related, and neutral words.

2.4.2 Activation of work vs. leisure concept

We asked participants to rate their agreement on two statements on a Likert-scale from 1 (not at all) to 5 (very much) to measure activated concepts: “Do you feel like you are in a ‘work mode’ right now?” and “Do you feel like you are in a ‘leisure mode’ right now?”.

2.4.3 Concentration

Objective concentration: KONT-P

We used a shortened version of the “Konzentrationstest KONT-P” (Satow, 2011) to measure concentration in terms of *accuracy* and *speed* in two subtests (calculating and counting), and *efficiency*, *accuracy increase*, and *speed increase* in the overall test. Both subtests consisted of five pages with 7 rows each and were presented in randomized fashion. Participants were asked to solve as many rows as possible within 20 seconds, then the next page followed (see Figure 3).

Please solve the following arithmetic tasks as fast and carefully as you can	Please count how often the number 1 appears in a row
1 + 1 + 1 + 1 + 1 =	1 1 1 1 1 2 2 1 1 2 2 2
2 + 2 + 2 + 2 + 2 =	1 1 1 1 1 1 1 1 1 2 2 2
3 + 3 + 3 + 3 + 3 =	1 2 1 1 1 2 2 1 1 2 1 2
1 + 2 + 1 + 2 + 2 =	2 1 2 2 1 2 2 1 1 2 1 2
1 + 0 + 1 + 0 + 1 =	1 1 2 1 1 1 2 1 1 2 2 1
3 + 1 + 3 + 3 + 1 =	1 1 2 1 1 2 2 2 1 2 2 2
3 + 4 + 4 + 4 + 3 =	1 1 1 1 1 1 2 1 1 1 1 2

Figure 3. Example of one page in the calculating subtest (left) and one page in the counting subtest (right).

Subjective concentration: Ratings

We assessed subjective concentration by means of three questions: “How satisfied are you with your own performance?”, “How concentrated do you feel?”, and “How motivated do you feel?”. Participants rated their agreement on a Likert-scale from 1 (*not at all*) to 6 (*very much*).

3. Results

T-tests for independent samples computed differences between *work* and *leisure* conditions. Means and standard deviations are reported merely for significant differences.

3.1. Hypotheses

H1: Reported *work* and *leisure mode* did not differ between participants reading *work*-related or *leisure*-related words. This held true for the field experiment (*work*: p = .146; *leisure*: p = .335) and for the laboratory experiment (*work*: p = .642; *leisure*: p = .679).

H2: In the field and in the laboratory experiments, results revealed no significant differences between participants reading *work*-related or *leisure*-related words regarding objective concentration, either for *efficiency* in both subtests (field experiment: p > .392; laboratory experiment: p > .067) and *speed* in both subtests (field experiment: p > .251; laboratory experiment: p > .688), or for *accuracy* (field experiment: p = .699; laboratory experiment: p = .132), and *speed increase* (field experiment: p = .450; laboratory experiment: p = .302) in the overall test. Contrary to our hypothesis, *efficiency increase* was significantly higher in the *leisure* compared to the *work* condition, t(84) = -2.45, p = .016 (see Table 2) in the laboratory but not in the field experiment (p = .286).

H3: In the field experiment, results revealed no significant differences in participants' satisfaction with their own performance (p = .387) and subjective concentration (p = .076). However, subjective motivation was significantly higher in the *work* compared to the *leisure* condition, t(60) = 2.83, p = .006 (see Table 2). We did not find any significant differences in the laboratory experiment for subjective measures (all p > .319).

Table 2

Means and standard deviations for significant t-tests for independent samples in the field and the laboratory experiments.

		Scrambled sentence test	
		Work-related	Leisure-related
Experiment		*M* (*SD*)	*M* (*SD*)
Field	Subjective motivation	4.84 (1.14)	4.07 (1.01)
Laboratory	Accuracy increase (KONT-P)	2.84 (3.37)	4.64 (3.24)

3.2 Post hoc analyses

We analyzed whether reported *work* vs. *leisure mode* correlated with *objective* or *subjective performance*. We found three correlations of reported *work mode* with subjective and objective measures in the field experiment, and three correlations of reported *work* and *leisure mode* with subjective measures in the laboratory experiment (see Table 3). Results indicate that when there was a stronger activation of *work mode* (or a weaker activation of *leisure mode*), *subjective concentration* and *speed* were higher in the concentration test. All other correlations of reported *work mode* and concentration and reported *leisure mode* and concentration were non-significant (all $p > .050$).

Table 3

Significant correlations (spearman correlation coefficient *r*) of work or leisure mode with subjective and objective concentration measures for the field and the laboratory experiments.

Experiment	Correlations		*r*	*p*
Field	Work mode &	Subjective concentration	.49	< .001
		Subjective motivation	.41	= .001
		Speed (counting subtest)	.25	= .048
Laboratory	Work mode &	Subjective concentration	.31	= .004
		Subjective motivation	.47	< .001
	Leisure mode &	Subjective concentration	-.25	= .018

4. Discussion

Previous studies found that activated concepts affect cognitive processing and behavior (e.g., Förster et al., 2005; Kay et al., 2004). We used a scrambled sentence test to activate a work (vs. a leisure) concept and assessed activation of work and leisure mode, objective and subjective concentration. In the field, participants conducted the experiment wherever they wanted, which included work but also leisure environments. To control for potential effects of surroundings, we repeated the experiment in the laboratory but found similar results indicating a negligible influence of surroundings on the experimental results.

In both studies, participants reported neither a stronger activation of work mode after completing a work-related scrambled sentence test nor a higher leisure mode after completing a leisure-related one. In addition, no noteable differences in subjective and objective concentration were found between work and leisure conditions. Manipulation of concepts did not affect performance, either because work vs. leisure concepts were not succesfully (or not sufficiently) activated or played no role in influencing concentration.

Although the scrambled sentence test has been used successfully in the last several decades, it has also aroused criticism (e.g., Doyen et al., 2012). We cannot verify whether it activated the intended concepts in our studies. Additionally, because cognition is situated (e.g., Wilson, 2002) there are a lot of situational variables that might have distorted the effects. Barsalou (2016, p.9) points out that "direct pathways from primes to primed responses rarely, if ever exist. " Additionally, Aarts and Dijksterhuis (2003) suggested that the mere confrontation with a prime without an action-relevant goal might not be sufficient to affect behavior: a picture of a library only activated corresponding behavior when participants believed that they would visit this library later on. Reading work-related vs. leisure-related words might not have activated an action-relevant goal. Furthermore, it has been shown that primed processes interfere with previously activated processes (e.g., Gollwitzer, Sheeran, Trötschel, & Webb, 2011; Bargh, 2006). For example, Shah and Kruglanski (2002) showed that priming a goal is unsuccesful if there is already another goal active. In our studies, participants might have prepared themselves mentally before they started the experiment, which might have interfered with the concept priming. The cover story might have reminded them of an exam situation (measuring language ability and numerical aptitudes), which association might have activated a goal (e.g., "do your best"). Other methods of concept activation and a reliable way to measure it are required for future research.

Although the scrambled sentence test did not affect participants' reported work or leisure mode, it still had an effect on concentration: correlation analyses showed that when reported work mode was higher (or the leisure mode was lower), subjective concentration, motivation, and speed in the concentration test were higher. Because the feeling of being in a *work mode* was not activated by the priming task it might have already been present, either because of the experimental situation which might have resembled a work or test setting, or even because of thoughts about pending work tasks. Regardless of how work mode was activated, it had a positive effect on concentration and, what is very interesting, was not affected by priming at all. An active work mode seemed to enable participants to perform well independently of current surroundings and any disruptive influences seemed to be suppressed. As correlation analyses do not provide insights in causal relations, future research should examine these relationships in more detail as they are of high practical relevance.

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Appendix C - Declaration of personal contribution

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Mathematisch-
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Erklärung nach § 5 Abs. 2 Nr. 8 der Promotionsordnung der Math.-Nat. Fakultät
-Anteil an gemeinschaftlichen Veröffentlichungen-
Nur bei kumulativer Dissertation erforderlich!

Declaration according to § 5 Abs. 2 No. 8 of the PromO of the Faculty of Science
-Share in publications done in team work-

Name: Carolin Patricia Burmeister

List of Publications

1. Environmental effects on cognition and decision making of knowledge workers
2. Ubiquitous Working: Do Work Versus Non-work Environments Affect Decision-Making and Concentration?
3. Have a look around: The effect of physical environments on risk behaviour in work-related vs. non-work related decision-making tasks
4. Office versus leisure environments: effects of surroundings on concentration
5. Does priming a work versus a leisure concept affect concentration performance?

Nr.	**Accepted for publication yes/no**	**Number of all authors**	Position of the candidate in list of authors	Scientific ideas of candidate (%)	Data generation by candidate (%)	Analysis and Interpretation by candidate (%)	Paper writing by candidate (%)
			Optional, the declaration of the own share can also be done in words, please add an extra sheet.				
1	Yes	5	2	30	0	80	70
2	Yes	3	1	70	90	90	70
3	No	3	1	80	90	90	80
4	No	3	1	80	90	90	80
5	No	3	1	90	90	90	90

I certify that the above statement is correct.

[redacted]

Date, Signature of the candidate

I/We certify that the above statement is correct.

[redacted]

Date, Signature of the doctoral committee or at least of one of the supervisors