Light on and in context

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Inaugural lecture
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/ Department of Industrial Engineering & Innovation Sciences

TU/e Technische Universiteit
Eindhoven
University of Technology

Light on and in Context

Where innovation starts

Inaugural lecture prof. Yvonne de Kort

Light on and in Context

Presented on November 13, 2015
at Eindhoven University of Technology

Light on context

"We rarely appreciate the robust power of situations. We look right past them, hidden in plain sight" Sommers, 2011, p.17

THE POWER OF CONTEXT

"*Seemingly trivial aspects of daily situations determine whether we keep to ourselves or get involved in the affairs of others, whether we follow a group or stake out an independent path, why we're drawn to certain people and away from others.*" (Sommers, 2011, p.17)

The ties between our social context, our spatial, physical and technological environment and human experience are many and this web of relationships does not easily lend itself to a comprehensive discussion, nor to all-inclusive investigation. And yet this is the domain that I chose to be my area of expertise, the domain of environmental psychology – both mundane and profound, applied and fundamental, wide enough to accommodate my many interests and yet, as a research domain, small enough to feel at home in.

There are a number of people crucial to the development of this field. Roger Barker for instance, a man who in the 1960s embarked in an innovative research project, observing and methodically recording children's behaviors throughout the day, including their interactions with others, with objects, and with places. This was a laborious and quite rebellious approach at the time, but his work – and that of his group – taught us the important and perhaps astounding lesson that the settings we find ourselves in often govern our behavior more strongly than do our individual personalities. In other words, he was one of the first to empirically lay bare the power of context.

"Throughout history, people of all cultures have assumed that environment influences behavior. Now modern science is confirming that our actions, thoughts, and feelings are indeed shaped not just by our genes and our neurochemistry, history and relationships, but also by our surroundings" Gallagher, 1993, p.11

DEFINING CONTEXT

The Oxford online dictionary defines the word context as "*the circumstances that form the setting for an event, statement, or idea, and in terms of which it can be fully understood*". According to this same source, its origin may be found in the Latin contextus, from con- 'together' and texere 'to weave'. Context thus, according to this definition, forms the setting for things we do, say, and think; and, in turn, is necessary to interpret the things we do, say and think. The origin of the word additionally suggests that contexts bind things together: who and what is there, what happens, what is said and what is thought.

The deceptive simplicity of the term context is readily apparent when studying the assortment of definitions and taxonomies proffered in scientific literature. In linguistics, context often refers to the text or speech surrounding an expression (word, sentence, or speech act) and influencing the way an expression is understood. In psychology, context sometimes refers to the task at hand, at other times to an individual's social context: whether they are alone or with others, and what type of others. In mobile computing it may refer to location or to a broader range of factors including people, situation and surroundings (Kjeldskov & Paay, 2005); or to social, psychological and physical factors (Tamminen, Oulasvirta, Toiskallio, Kankainen, 2003).

We can safely conclude that there is no general definition or static taxonomy of the term context. More importantly, context is such an all-embracing term that any attempt to thoroughly discuss its impact on behavior and experience is bound to fail. In addition, context is not static, but dynamically changing, it is relational rather than informational, and not something 'out there', but something that arises from activity, and, as such, is inseparable from user and user experience. Researchers in the domain of environmental psychology, therefore, generally argue for studying environment-behavior relationships as a unit rather than separating them into supposedly distinct and self-contained components (Bell, Greene, Fisher, & Baum, 2001). Most of them adhere to interactional, transactional or even holistic views of environment and social and behavioral processes, treating experience as inseparable from context (e.g., Altman & Rogoff, 1987; Dourish, 2004; Wapner & Demick, 2002; Werner, Brown, & Altman, 2002). Proshansky (1976), one of the founding fathers of this field stated: '*There is no physical setting that is not also a social and cultural setting*' (p.67).

CONTEXT AND TECHNOLOGY

Can our understanding of context inform the design of new technologies? Throughout my career, I have focused on people in their socio-spatial context, i.e. I have studied behavior and individuals' experience of and interaction with technology in light of their physical, interpersonal and socio-cultural context. This contextual perspective I believe is crucial in contemplating, designing and implementing new technologies. And through delivering this lecture I hope to convince you of the same: that we only come to understand the emotions, cognitions and actions of individuals in their contexts, and that therefore we need to understand contexts and their influence on human experience to make technology work.

Luckily the import of understanding context is recognized and explicated by important scholars in the field. For instance Malcolm McCullough states that: "*When information technology becomes part of the social infrastructure, it demands design consideration from a broad range of disciplines. Social, psychological, aesthetic, and functional factors all must play a role in the design. Appropriateness surpasses performance as the key to technological success. Appropriateness is almost always a matter of context*." (McCullough, 2004, p.3) In other words, the question becomes not whether and how the technology or a technological artifact works, but how it serves the needs of the users in that particular space and social setting, at that particular time. This also resonates with the original meaning of context: the integration of ourselves and our surrounding elements into a coherent single stream of experience. This certainly implies that one has to know and understand contexts in order to develop technology that works for its users.

"The most profound technologies are those that disappear [...] they weave themselves into the fabric of everyday life until they become indistinguishable from it" Weiser, 1991

CONTEXT AND (MEDIATED) SOCIAL INTERACTION

One of the first international and interdisciplinary projects I participated in was the 6th framework EU project PASION. With a mix of German, British, Italian and French researchers from universities and industry, and friends in the department of Industrial Design, we (Wijnand IJsselsteijn and myself) hoped to advance mediated communication by enriching it with information on location, place and emotion. Since mobile communication is essentially de-contextualized, it lacks a lot of information that is passed along in the real-world communication.

I enjoy talking to people in person, but I hate talking on the phone. This has only gotten worse since the introduction of the mobile phone. Today when we call someone, we have no way of knowing where they are. In fact, the most frequently uttered opening sentence of mobile conversations may well be: 'Where are you?' (Schmidt, Takalouma, & Mäntyjärvi, 2000). But the simplicity of this question may be misleading. Geographical location – for instance in GPS coordinates – is rarely of interest to the conversation partner (e.g., Arminen, 2006; Laurier, 2001; Weilenmann, 2003). Instead, telling the location in mobile telephony serves mainly social functions. It tells us whether someone is available, whether they can talk privately, it may suggest how they are feeling, or in what state of mind they are, it may provide food for conversation, or may even trigger them to invite us to come over or do something together. All of this information we lack in mediated conversations, and get for free when we share a space, and share a context.

Spatial context structures and organizes social interaction. This desk from behind which I am speaking today gives me something to hold on to. It provides a sense of security to the speaker while addressing an audience this size. At the same time, you are all seated in chairs, which are fixed to face me. Contexts thus lay out the rules for interaction; they set the scene and outline the program of behaviors (Barker). It would be so much harder to make you listen to me if this was a playing field or a supermarket.

Physical spaces also trigger and enrich social interaction. In a study on emergent urban places, Vyzoviti (2005) investigated relationships between the morphology of urban areas and social interaction. Easy access and affordances for sitting, leaning, placing food and drinks, and watching others were shown to be essential characteristics for emergent places. Notably, these findings were common to groups as diverse as young Dutch skaters in Tilburg (the Netherlands) and ethnic immigrants in Athens (Greece) and they are still very much in accordance with William Whyte's (1980) famous observations reported in his 'Social life of small urban places'. His research (and that of many others, e.g., Festinger, Schachter, & Back, 1950; Fleming et al., 1985, Hillier & Hanson, 1984; Lynch, 1960; Osmond, 1957, Skjaeveland & Gärling, 1997; Sommer, 1967; Sommer, Herrick & Sommer, 1981) has generally indicated that social contacts are enhanced by opportunities for passive social contact – being in the presence of others, being able to see them, and to make eye contact. Spontaneous interaction also requires comfort, aesthetics and content for conversation: an object, event or third person to talk about – a principle Whyte coined 'triangulation'. But equally important are a sense

of safety and security, and perceived control over the conversation: being able to end the conversation and leave at will, yet preferably without offending the other.

Socio-spatial context is, in fact, part and parcel of social interaction. Goffman (e.g., 1956, 1961, 1963, 1967), Osmond (1957), Hall (e.g., 1959, 1966), Sommer (e.g., 1959, 1961, 1967) and Argyle and Dean (1965) were the first scholars to perform intensive and structured observations of the use and meaning of space in interpersonal communication. They recognized that spatial behavior, particularly interpersonal distance, was very much a part of social interaction. As people approach each other, they gradually share more information and additional senses come into play. Argyle and Dean (1965) proposed that interpersonal distance, body orientation, gaze and smiling all contributed to intimacy and involvement. Their equilibrium theory proposes that if one of those behaviors results in a deviation from the optimal level of intimacy, this would be compensated by other behaviors. In parallel, Altman (1975) also conceptualized interpersonal distance as one of a host of information regulation mechanisms to achieve optimal privacy. Importantly, these interpersonal spacing processes also apply in mediated social interaction (Lombard, 1995), virtual environments (Jeffrey & Mark, 1998) and in interactions with virtual persons (e.g., Bailenson, Blascovich, Beall, Loomis, 2001; Bailenson et al., 2005; Hoyt, Blascovich, & Swinth, 2003; Janssen, Bailenson, IJsselsteijn, Westerink, 2010). Whether or not interaction is mediated or augmented through technology, people's spatial behavior is a dynamic and integral part of communication: it is an interaction tool to guide and facilitate communication, intimacy and involvement.

In turn, social context turns physical spaces into meaningful places. Spaces become places in the presence of social actors and social acts – a phenomenon also termed social navigation (Dourish & Chalmers, 1994; Munro, Höök & Benyon, 1999). In daily life, people observe activities, facial and bodily expressions of others and deduce general emotions and atmosphere – the presence of others often is a powerful recommendation for a place – and social contexts may aid in spatial navigation: crowds, their flow through space, queuing lines of people et cetera provide important cues to orientation and wayfinding for visitors of unfamiliar places. Alternatively, if others are not present while one visits a place, users may read the traces of past presence and behavior (Zeisel, 1980). From these traces one can tell frequently used spaces and paths from less popular ones, the type of use and activities in places, the types of users as well as their attachment to the place.

So we see that contexts may lure in, lubricate and lay out the rules for social interaction. If designed well, they empower their users, enrich conversation and become a means of communication. These perspectives represent important ways through which our social and physical contexts co-act to shape interactions and our experience of them. Good places to meet are comfortable, invite people in and persuade visitors to stay. They are rich with pleasant stimuli, providing opportunities for triangulation, and – crucially – they give visitors actual and perceived control over social interaction, by giving them information on other users, offering them the opportunity to scan social environments before entering, and decisional control over engaging in or withdrawing from interaction.

The perspectives I presented here also define potential directions for contextually aware communication technology and applications. For instance, by augmenting spaces with layers of (real-time or traced) social and emotional information, thus creating more meaningful places; by improving ways for triangulation, reciprocation and equilibration in audio or video-based communication; or by finding parallels to the organizing principles of physical settings to help improve group collaboration over computer networks. Mediated communication could be re-contextualized to better support experiences of togetherness, natural fluency and intimacy.

CONTEXT AND PLAY
Shortly after we had started the PASION project, we acquired not one, but two EU projects around the phenomenon of digital games: FUGA and Games @Large. These allowed us to collaborate with psychologists and gaming experts across Europe, form an entirely new team of researchers in our group and open our Game Experience lab. A wonderful group of people and definitely a hot topic, but how was an environmental psychologist to add to this domain when digital gaming is often portrayed as one of the most socially-isolating and context-negating activities to date?

In spite of concerns raised by teachers, parents, researchers and policymakers (Bryce & Rutter, 2003), the literature does not provide convincing evidence to this effect. On the contrary, there are a number of studies demonstrating that games often benefit not only cognitive skills, but also social talents (Calvert, 2005; Gunter, 2005). Focus group research we performed ourselves clearly demonstrated that digital game play is suffused with social motivations, interactions and effects (Poels, de Kort, & IJsselsteijn, 2007). We therefore argue that gaming is often as much about social interaction as it is about interaction with the game content.

Thus, the experience of gaming can only be fully understood when the game is conceptualized as more than the software and hardware the gamer is interacting with locally, and includes the social-contextual contingencies that powerfully influence game experience: co-players, audience and their spatial organization, which shapes play and social interaction.

We developed a theoretical framework of digital gaming as a situated experience, describing social processes underlying situated social play experience and how the game's socio-spatial and media context help shape it (de Kort & IJsselsteijn, 2008). It considers these 'sociality characteristics' of co-located and mediated social game settings (e.g., visibility, communication channels) as means that allow for important social processes – e.g., monitoring, mimicry, reciprocation – and for experiencing togetherness. This shared experience nurtures the fundamental human need for relatedness. Digital games, which are generally already strong in fostering autonomy and competence, could thus complete the triad of need fulfillment (Deci & Ryan, 2000) and would produce even more motivating and fulfilling experiences.

While with Karolien Poels and Wouter van den Hoogen we developed ways to capture, characterize and measure player experience, with Brian Gajadhar we experimentally put our model to the test and found many of our hypotheses confirmed (e.g., Gajadhar, de Kort & IJsselsteijn, 2009, 2011). It does really add to the fun if you play with someone, and more so if you can see their expressions, hear their moans, giggles and screams, and share their local and/or virtual context. These factors even appeared more important than whether you compete or collaborate, win or lose, or who exactly you are playing with. Digital gaming will be more intensely enjoyed if we find better ways to integrate meaningful communication channels and to design for co-experience. In other words, if we succeed in merging individual players' magic circles into one shared social context.

CONTEXT AND STRESS RESTORATION
But sometimes it is not so much social context, but rather our escape from it, from its pressures and scrutiny, that we seek. Restorative effects of environments – natural environments that help us unwind, reflect, and cope with chronic or acute stress (Ulrich, 1983; Kaplan & Kaplan, 1989) – have been at the center of my attention for quite some time. The research initially addressed aspects of form when we explored what characteristics of media technology (e.g., screen size, parallax) would be most relevant for making experiences of mediated (televised,

simulated) nature scenes as beneficial as a walk in a real forest (e.g., de Kort, Meijnders, Sponselee, IJsselsteijn, 2006).

Currently, our research centers more on content – *what* should be depicted, which contexts carry restorative potential – and *why* this is so. In our extensive collaboration Femke Beute and I have explored whether restorative effects are driven purely by the number of natural elements, or also by the amount of (day)light, or weather conditions (e.g. Beute & de Kort, 2013, 2014a, 2014b). We are trying to learn who benefits most from exposure to nature – comparing for instance clinical with non-clinical groups in collaboration with GGzE. Naturally, we do not perform these studies only in the confines of our laboratories. Experience sampling and quantified-self approaches are crucially providing us with insights in the ongoing dynamics of stress and restoration in the context of real life. These insights speak of the importance of those little escapes to nature for mental health and wellbeing, and they will be able to help us shape applications that offer restoration exactly when and where it is needed – temporarily drawing people out of their local, stressful context and offering them an alternative one to replenish resources or protect them against future stressors. At the very least, they are instrumental in raising awareness of the importance of context, and how the environments we find ourselves in may harm or, conversely, serve to protect us in our daily lives.

TECHNOLOGY AND CONTEXT
Over the past decades, our environments have increasingly become permeated with technology – a process that will continue with growing intensity. By augmenting our physical spaces and social settings with technology, we have introduced technology into our daily contexts. I am not saying that this is either good or bad, it is simply a statement of fact. But one can envisage very different scenarios of this future world replete with technology. In a recent book, David Rose (MIT) sketches two possible extremes: at the one end we find 'Terminal world', in which "*the cold, black slab has re-architected everything – our living and working spaces, our schools, airports, even bars and restaurants. We interact with screens 90 percent of our waking hours" (Rose, 2014, p.2)*. At the other end, he drafts a world full of 'enchanted objects', products that are '*engaging and essential, that resonate with the latent needs of those who use them, and that create an emotional connection with us human beings'* (p.xi).

The problem, of course, is that we generally do not realize to what extent and how deeply we may be impacting lives when introducing new technologies. Most of the

time, we are not aware of this impact even after we have started using them. One striking illustration of this to me is the iPhone effect, coined by Misra and colleagues (2014), which contends that the *mere presence* of a mobile device – not its use, just its passive being there, on the table – negatively impacts empathy and closeness in a conversation. Mobile devices offer us a direct connection to all of our friends, the means to capture special moments, people and places, and carry them with us at all times; they offer us access to limitless information. Most of us embrace them as the perfect escape out of a boring or otherwise unrewarding local context. They are the literal world at our fingertips. But this very escape, or the mere promise of it, may also draw us out of contexts we did – or should – actually want to experience to the full.

I do not claim to know how we will fare in a world where every object, room and street has intelligence and is ready to engage and interact with us, or whether we will be enchanted or estranged by it. I do not know whether, in the end, media technology will bring people together, or drive them apart. I do not know whether we will still be able to 'switch off' in a world that is always on. But I do know that we should treat these issues with unremitting care and attention, for they are touching our habitats and through them our very existence. We are reshaping our contexts, and as such are largely inadvertently and unknowingly reshaping ourselves, and the things we do, say, think and feel.

To sensitize ourselves to just what extent one technology, adopted in our private contexts, can impact public and private life and bring about societal changes, let us consider artificial light: When artificial light was installed in city streets, dusk no longer dictated that we stay indoors. We conquered the night and public nightlife emerged. In factories, gaslight and later electric light made it possible to work around the clock, offering a revolutionary rise in productivity and providing quintessential conditions for the rise of our 24/7 economy. In private homes, the introduction of electric light and central heating ended the era of family evenings around the hearth (Freeberg, 2015).

We forget just how painfully dim the world was before electricity. A candle, a good candle, provides barely a hundredth of the illumination of a single 100 watt lightbulb. Open your refrigerator door, and you summon forth more light than the total amount enjoyed by most households in the 18th century. The world at night, for much of history, was a very dark place indeed. (Bryson, 2010, p.122)

Light became ubiquitous: wherever people went, there light went too. *"the light was creating them — changing their relationship to the natural world, shaping the rhythm of their days, and transforming their culture."* (Freeberg, 2015)

Artificial light has indeed woven itself into the fabric of our daily lives. In fact, it has become a contextual element so commonplace, that we have forgotten to notice it. But electric light has been both cause and catalyst of gargantuan societal changes and today, on a daily basis, deeply impacts our health, our effectiveness, and our mental welfare.

Light in context

"Why at the beginning of things is there always light?" (Flanagan, 2014)

THE POWER OF LIGHT

Light is one of our most indispensable resources on this Earth. Light is also one of the most powerful elements of context. It makes the world visible to us. It is often used as a means to create atmospheres and can powerfully influence cognition, mood and emotion. Moreover, light is the major driver of the 24-hour sleep-wake cycle, so it entrains our biological clock, regulates sleep and hormonal processes. It acutely influences alertness, vitality and performance and is a crucial determinant of both physical and mental health. It is therefore hard to overestimate the impact light has on humans – biologically, psychologically and socially.

Light is a phenomenon that has fascinated researchers across domains of physics, engineering, architecture, physiology, biology, neuroscience and psychology. Surprisingly, though, light and lighting have not received much attention in environmental psychology. Over the past few decades, its highest-ranked journal featured less than one article per year on the experience or psychological effect of light or lighting (de Kort & Veitch, 2014). Perhaps this is due to light's ubiquity and the '*anesthetic of familiarity*' to borrow a phrase from Richard Dawkins: "*a sedative of ordinariness which dulls the senses and hides the wonder*" (Dawkins, 1998, p.6). But this we need to change.

"[L]ight affects our circadian rhythms more powerfully than any drug" Czeisler, 2013, S13.

DEFINING LIGHT

Light is defined as the part of the electromagnetic radiation spectrum that can be detected by human photoreceptors (the well-known rods and cones) in the outer layer of the retina in the human eye, i.e., radiation with wavelengths between ~380 and ~780 nm.

Objects, people, scenes or events do not become visible to us until light – photons emitted, reflected or refracted – falls onto our retina and innervates the photoreceptors. This sets off a cascade of signals through the optic nerve, via the optic chiasm and lateral geniculate nucleus to arrive at the visual cortex (the so-called geniculostriate pathway), giving rise to visual experience.

"We have only to open our eyes, and spread before us lies a banquet of colors and shapes, shadows and textures: a pageant of rewarding and threatening objects, miraculously captured by sight All this, from two tiny distorted upside-down patterns of light in the eyes.." Gregory, 1998, p.1

Little over a decade ago, we came to know that an additional type of photoreceptor resides in the inner layer of the retina. This newly discovered receptor, named intrinsically photosensitive retinal ganglion cell (ipRGC; Berson, Dunn & Takao, 2002; Hattar, Liao, Takoa, Berson & Yau, 2002), produces the strongest input to an additional pathway for light information into subcortical parts of the brain – the brainstem, hypothalamus and thalamus – as well as regions in the limbic system and frontal cortex (Vandewalle et al., 2006, 2007, 2009). This retinohypothalamic pathway is often referred to as non-image forming because it does not – at least not directly – contribute to our visual experience. In fact, nothing of the 'image' is retained in the signal except for the amount of light falling onto the retina. But this information impacts the timing of circadian rhythms and it directly modulates alertness and ongoing cognitive processes (Cajochen, 2007).

LIGHT AND BIOLOGY

The non-image forming (NIF) pathway is often referred to as the biological pathway of light, because of its ability to modulate physiology and brain activity directly, i.e., outside of our conscious awareness and irrespective of the visual experience. For decades, we have been aware of the fact that – like virtually all organisms on this planet – humans also live attuned to the 24-hour cycle of light and dark, and that light is the most important external cue to keep our internal circadian rhythms entrained with that of our environment, i.e., a Zeitgeber.

In synchrony with the rise and fall of the sun, animals awaken and sleep, plants open and close their blossoms, plankton travel up and down the water column. All these rhythms are controlled by a biological clock that represents the twenty-four-hour day of our planet. Roenneberg, 2012, p. 2

For a healthy entrainment, we need sufficiently bright light during the day and darkness at night, much as we would have had when we lived in caves. But these days, the majority of our time is spent indoors. The amount of (electric) light we experience there during daytime is typically much less than we would be getting outside, while the opposite is true for evenings and nights. This is thought to be one of the major reasons why we sleep substantially less and less well than we did before the age of urbanization and modern (screen) technology in our homes. In a BBC interview, Russell Foster – one of the discoverers of the ipRGCs – said: "*We are the supremely arrogant species; we feel we can abandon four billion years of evolution and ignore the fact that we have evolved under a light-dark cycle*". And light not only powerfully modulates cognition and physiology through shifting or entraining circadian rhythmicity, it also produces direct effects on brain activity, physiology and behavior, including alertness and performance (Cajochen, 2007).

Environmentally minded scientists have begun to question the trade-offs we unwittingly make in order to lived sealed up inside an artificially heated, cooled, and lighted world."
Gallagher, 2007, p. 13

The exact workings of our biological clock and how it is impacted by light exposure is studied by chronobiologists – biologists of time. They have developed very stringent protocols to investigate the characteristics of circadian rhythms of physiological, neuroendocrine and psychological processes, such as constant routine and forced desynchrony. These allow them to isolate the effects of light from those of other relevant factors including for instance food intake, physical activity, sleep or room temperature. The effects are generally studied on objective and robust indicators of bodily functioning termed biomarkers, the most important one in this particular context being melatonin. Melatonin is our sleep hormone and its concentration in blood starts to rise in the evening – as the body is preparing itself for sleep – and declines in the early morning. Exposure to light during those nightly hours suppresses the release of melatonin in the blood, resulting in higher alertness and physiological changes. This highly controlled and often nocturnal or around-the-clock work was imperative in understanding the non-image forming pathway and the inherent convolution of light, time and human functioning.

Unfortunately, the intricacies of this domain are not always taken into account sufficiently when translating research to real-world light applications. If chronobiology teaches us anything it is that our bodies are radically different during for instance day versus night, or after serious sleep deprivation versus

a good night's rest. Still, sometimes people are inclined to literally transpose findings from nocturnal studies or 40-hour awake protocols to daytime office lighting. For instance, because blue-spectrum light has proven extremely effective in suppressing melatonin production, it is often assumed that blue-enriched light should also produce higher alertness and cognitive performance during the day. This, however, is not necessarily the case (e.g. Sahin & Figueiro, 2013; Smolders & de Kort, submitted).

In the NIF domain our group's goal is to contextualize light research. We perform diurnal, translational research of non-image forming processes for day-active persons. This is an area of research I defined together with Karin Smolders. In our close collaboration, we have tested effects of light exposure on people who see the sun every now and then, navigate the physical world – biking, walking – sleep, eat and drink their number of espressos (e.g., Smolders de Kort & van de Berg, 2013; Smolders, de Kort & Cluitmans, 2012, 2015). In other words, we study light effects in more naturalistic conditions and explore various affective and cognitive processes, relevant for daily life. We are very lucky in having found in Laura Huiberts, a motivated and talented candidate to continue this line of work with us, even though during the day, light is not always the magic lantern it promises to be at night (Huiberts, Smolders & de Kort, 2015). Also, in our collaboration with Philips in the lighting flagship and Impulse project, Adrie de Vries has embraced a very similar ambition, while our friends and colleagues at the department of Built Environment work to translate these types of findings to implications for architectural and lighting design.

LIGHT AND PSYCHOLOGY
A neurophysicist recently showed me a visual illusion he and his colleague had created a few years ago (Van Lier & Vergeer, 2008). It plays with the phenomenon of afterimages. Afterimages are a product of the adaptivity of our visual system, particularly, though not exclusively, in the retina. When we stare at a light source for too long, our photoreceptors adapt to this overstimulation and lose sensitivity. Hence we see a dark spot in our visual field after fixating on a bright source, as if the photonegative of the former image is overlaid onto our current view. Similarly, if we look at colored sources, we will see a similarly shaped afterimage in their complementary color. For instance, for a greenish source the afterimage will be pinkish, and vice versa. But their illusion demonstrates that we will selectively see only one afterimage of two overlaid, differently colored objects, depending on the outline of the shape that is depicted during the afterimage. We even selectively fill in the two outlines if they are presented in succession or at different locations.

Illusions such as this to me are exceptionally good at demonstrating the niftiness, adaptiveness and complexity of our visual system, and why perception belongs to the domain of psychology.

Light is an element of context that is often under our deliberate control, amenable to our needs, and dynamically tunable to scenes as they unfold. We know that contexts influence our experience, color our thoughts and feelings, make us see things in a different light in a metaphorical sense. Lighting could thus become a powerful tool for nudging people's behaviors in indoor or late-night outdoor settings. It could, for instance, gently persuade office workers to take a short break in between stressful tasks, motivate patients to open up to their therapists, stimulate children to listen patiently while others speak, or support managers in finding common ground in feisty discussions. This, however, would require a robust understanding of individuals' connotations with light, brightness and color. But what is the meaning of light? Why do we consider moonlight romantic, fluorescent light formal, or sunlight invigorating?

"The introduction of the electric light was everywhere dramatic. Often only nature itself, grandest of all spectacles, could provide a standard for comparison. [...] The electric light not only enhanced spectacles, it was a spectacle, captured in favorite descriptive metaphors of flowers, spider webs, lakes, and rainbows." Marvin, 1988, p.164

We may attach meaning to light and colors because of their repeated pairing with particular concepts, experiences or events – for instance through personal experiences, stories we hear or through culturally engrained usage. Additionally, some meanings may even be biologically based (e.g., Elliot & Maier, 2012). Unfortunately, to date we have no periodic table of the psychological connotations of hue, lightness or chroma, nor is it easy to systematize the effects light conditions have on human behavior. In the literature we find extremely intriguing, yet often mysteriously conflicting reports of the effects of color, light and brightness. For instance, darkness has been reported to facilitate the acoustic startle reflex in humans (Grillon et al., 1997); darker conditions have been demonstrated to increase dishonesty, self-interested behavior (Zhong et al., 2010) and aggression (Page & Moss, 1976); but, in contrast, darkness also increased cooperation (Steidle, Hanke, Werth, 2013), and made perfect strangers experience intimacy and seek more intense contact – or even cuddle (Gergen, Gergen, & Barton, 1973).

Equally contrasting effects are reported for color (e.g., see Elliot & Maier, 2012, 2014). In their review on color psychology, Elliot and Maier state that this domain is still in a nascent stage of development and I would argue the same for light psychology as a whole. Far less research has been performed on the psychology than on the (psycho-) physics, physiology and neuroscience of light. But, on the other hand, sufficient work has been performed to start developing a tentative framework of psychological mechanisms related to light. Considering light as a contextual cue, I believe three pathways are particularly relevant: one related to attention and (self-) awareness, one primarily affective in nature, relating to the experience of aesthetics and pleasure, and one grounded in cognitive associations.

Awareness pathway

Light has since long been employed as a means to guide awareness and attention: consider, for instance, the use of stage lights and spotlights in theatre. Brightness, placement and color as well as changes therein are instrumental for stage light designers in directing the audience's views and drawing them towards and into the story that is to be told. But also off-stage, dynamic and static characteristics of light may inherently capture attention and direct it to external cues or objects (Franconeri & Simons, 2003; Enns et al., 2001).

"[The stage light designer] soon learns that objects of higher brightness generally draw attention on stage. Light attracts! Conversely, darkness conceals - but may also put the audience to sleep. One of the prime jobs of the lighting designer is to actually keep the audience awake." Williams, 1999, Part One

A few years ago, Antal Haans and myself performed a study on dynamic street lighting, the results of which I found quite intriguing (Haans & de Kort, 2012). In this study we had a fairly basic and applied research question: if one dynamically lights the street for pedestrians, would they feel safer when visible and exposed – with light shining on themselves – or would they, instead, feel safer if they had prospect – and hence had the street lit in front of them. We hypothesized that prospect would be most important and that, therefore, our participants would prefer the latter option. Of course they preferred the former: the fact that participants behave against expectations is no longer surprising to us. But mystery did lay in the fact that persons reported to have more prospect in this first lighting condition. It really pointed out just how little we understood both vision and safety perception. I am pleased this set in motion a far more fundamental research line of Antal with Leon van Rijswijk, in which they investigate the

construction of safety perceptions in realistic environments and the cues people consciously and unconsciously use in this process (van Rijswijk, 2016).

Besides drawing attention to external cues, directed or bright light could also heighten *self*-awareness, whereas its counterpart, darkness, may trigger feelings of anonymity. In darkness we can go undetected, but in the spotlight, persons are vulnerable to the scrutiny of others. This may turn their attention to their inner states and traits, and prompt them to examine their personal norms and engage in better self-regulation (Carver & Scheier, 1979; Duval & Wicklund, 1972). Gergen et al., Page and Moss, and Zhong and colleagues all refer to this effect of bright versus dark settings in explaining their findings. Anna Steidle, our friend and colleague in Germany (Steidle & Werth, 2014) was the first to explicitly demonstrate that light indeed does raise self-awareness and individuals in brighter circumstances are more likely to employ self-regulation and exert self-control more automatically and effortlessly.

Affective pathway

Who is not fascinated by the dancing light of flames in a log fire or the mesmerizing play of sunlight on water? Light can create beauty, accentuate beauty, and is sometimes equated to beauty. An alternative psychological pathway through which lighting may affect people, therefore, is through aesthetic appreciation and comfort. Experience and behavior are, of course, strongly influenced by affect. This has been demonstrated abundantly in psychological literature on processes as diverse as creativity, decision-making, challenge-threat appraisals and risk-taking, and interpersonal processes such as helping, person appraisal and affiliative interaction or aggression (e.g., Baron, 1987; Blascovich & Mendes, 2000; Fredrickson & Joiner, 2002; Isen, 1987). Moreover, affect and mood show strong (predictive) ties to objective and subjective health (Pressman & Cohen, 2005).

when the light shifts
countless trembling
raindrops on birch twigs
fade to a clarity that seems
the temper of the day
until light returns
to the shining tree
Clark, 2014

Literature indicates that light can indeed influence mood, although this is generally better understood for natural than for electric lighting. Mood has, for instance, been positively related to daylight (Kaida, Takahashi, & Otsuka, 2007; aan het Rot, Moskowitz, & Young, 2008) and particularly sunlight (Denissen, Butalid, Penke, & van Aken, 2008; for a review see Beute & de Kort, 2014). But electric lighting too, may be related to positive mood. In domestic, retail and care

settings, lighting is designed to create positive and attractive atmospheres. Research has demonstrated that in these contexts, color is a very influential attribute of lighting (Kuijsters et al., 2015; Küller et al., 2006; Vogels, 2009) and that especially color evokes affective responses (Knez, 2001). For the creation of atmospheres to this end we currently have to rely purely on the intuition and expertise of light designers, as it is notoriously hard to draft the formula that will combine brightness, color and placement of light into for instance a cozy or lively scene. But Mariska Stokkermans is one of the researchers in our group who tries to find structure in this process, a much-needed exercise if we want to create fitting and pleasant conditions for everyone.

In office settings, users' preferences and appraisals have been shown to indirectly influence work engagement and hence may contribute to employee effectiveness (Veitch, Stokkermans & Newsham, 2011). What is particularly important here is that preference – or actually dislike of, for instance, blue-enriched or overly bright settings – may well counteract any intended alertness or performance enhancing, non-image forming effects of light (Smolders, 2013). But, on the brighter side, converging evidence is suggesting that well-designed lighting conditions may elicit beneficial effects via this affective pathway of light on cognitive and social processes as well as health.

Cognitive pathway

Light not only directs attention and induces positive or negative affect, it also has meaning and hence can act as a cognitive contextual cue. This is true for brightness, as much as for color (Elliot & Maier, 2014). But, as I stated earlier, connotations with light may be volatile and varied across persons and situations. Color and light itself have been ascribed many meanings: red is the color of love, danger or dominance; blue is associated to calmness and relaxation or cold, green may be related to mystery, envy or naturalness and goodness. So if we want to communicate a certain denotation of light and color, how do we predict, or even determine its meaning? For this is what we need to be able to do if we want to employ lighting to guide people's actions and, for instance, nudge them into more pro-social and less aggressive behaviors in crowded settings.

With Anne Schietecat and Daniel Lakens, we are developing a theory to understand how people assign meaning to light – or actually any object or concept we encounter in daily life. This is a very fundamental and exceptionally challenging question, but also very exciting and essential for realizing urban nudging through light. So how can we understand how meaning is assigned to a specific light

condition? How can we understand, for instance, why bright light sometimes conveys 'goodness' – an aggression decreasing cue – when at other times it expresses 'activity' – an aggression enhancing cue? The answer to this question is of course: context.

Perception is all about contrast, and so is the subsequent process of giving meaning: it relies on contrast. Context provides the background against which concepts stand out and, in turn, this contrast represents a dimension on which to evaluate concepts. To illustrate this, consider the color white, which actually has a quite neutral connotation in and of itself. But if contrasted against black, the polar opposition of light and dark becomes salient, and since black is typically considered bad and immoral, white will be considered good and moral (Lakens, Semin, & Foroni, 2012). Now of course there are multiple dimensions on which we can place and then qualify specific concepts. Luckily, there are a few very basic dimensions underlying most of human assignment of meaning. In an elaborate set of studies, Osgood and colleagues (e.g., Osgood & Richards, 1973; Adams & Osgood, 1973) have determined the three most important ones: Evaluation, Activity and Potency. This theory provides the backbone for our framework and helps us understand that a bright white light may – because of its perceptual contrast to black – be associated with the positive end on the evaluative dimension, but may also – because of its contrast to dimmed or turned-off light – be associated with the high arousal end of the activity dimension. Which of the two meanings becomes salient depends, again, on context and the strength of the various contrasts it produces.

The meanings ascribed to light and color are context specific. A framework such as this offers a means to understand and systematize the role of context in deriving meaning from light or color. This would be instrumental in designing interactive light interventions for all sorts of applications. The results we have so far are extremely promising and I look forward to developing this framework further and testing its robustness and effectiveness in future research.

Context revisited

"To understand human nature, you must appreciate the power of situations"
(Sommers, 2011, p. 4)

IMPLICATIONS OF THE CONTEXTUAL PERSPECTIVE

It is difficult enough to perform research in controlled environments: to isolate individual dimensions of context and study light's interpretations in the controlled confines of the lab environment; or to disentangle effects of brighter light for different, yet well-specified cognitive tasks. But the task of designing and testing effective light settings in the real world is even more challenging.

Consider, for instance, a stretch of over fifty cafés and bars, with over 10,000 visitors each weekend – young, buzzing with energy and testosterone, often intoxicated with alcohol or drugs, and gradually more so as the night progresses. Then consider that this is our Petri dish: music is pumping, wind is blowing, police are trying to keep close watch on the street, while indoors bouncers work to keep their bars clear of unwanted elements. This is Stratumseind, our living Lab for the De-escalate project (de Kort et al., 2014). Here we have joined forces with the municipality, bar owners, Philips and the police to evaluate the effectiveness of dynamic lighting scenarios to defuse escalating behavior. Here we learn that no matter how promising a strategy looks in the lab, the real world is wild and unpredictable. Here we have to make sure that scenarios don't disappear in the cacophony of the crowds, noise and stray light, that they appeal to the wide variety of users, and that we somehow capture the subtle influence of our scenario on the street's atmosphere. This is light in context and this is a challenge that I thoroughly enjoy having taken on, but only because of our dream team: Indre Kalinauskaite and Antal Haans, the talented researchers doing all the hard work.

A similarly challenging project lies ahead in our collaboration with GGzE, where we hope to find that these de-escalating scenarios may also serve to help clients to regain self-control while frustrated, angry or otherwise aroused, and support their route to recovery. And, although perhaps less wild and exotic to most of us, office settings, too, provide very challenging contexts to optimize lighting conditions. For as soon as we step into the real world, we have to tailor to users of different ages,

chronotypes and light preferences; we have to learn to predict how they are feeling and what they will be doing; and we are no longer able to isolate image-forming (perceptual, awareness, affective and cognitive pathways) from non-image forming effects (acute and circadian). Engineering, design, psychology and biology together have to meet this challenge, as no single profession or discipline will suffice on its own.

CONTEXT 2.0
This very realization, that good lighting technology – or any interactive technology today in fact – requires a broad, multi- or even interdisciplinary perspective, is why I am proud that our university started the Intelligent Lighting Institute.

Its creation has uniquely facilitated a confluence of technological disciplines, design, and social sciences. This has been extremely inspiring and instrumental in developing the impressive research agenda we hold today. Because of this, Eindhoven is now, finally, also in academic terms the City of light, with over 30 ongoing PhD and postdoc projects, supported and supervised by a tight, interdisciplinary network of experts – internal and external to TU/e. There is a close and productive collaboration with Philips in the Lighting Flagship, and a tight integration with the municipality, user communities and other public parties. Together, we are ready to realize our translational agenda of research: bridging disciplines as varied as physics and psychology, mathematics and design, and translating fundamental research to innovative technological applications.

Today, we are drawing up the plans for a Humans & Technology Centre, an even more ambitious collaboration between multiple disciplines from the social sciences, humanities, design and technology, focusing on the importance of the human actor in technology research and development. With this, we as TU/e are taking a unique and visionary approach on innovation. I hope that the lessons we learned within ILI will help smooth the process of cross-disciplinary cooperation and finding true synergy there.

Both concrete projects to collaborate in as well as living labs are instrumental for making interdisciplinary teamwork a success. It is impossible to study the intelligent services and applications we envisage today in isolated laboratory contexts alone: valid insights on emergent patterns of use and their effects – e.g., on health, productivity, communication, or energy expenditure – require the scale, unpredictability, and complexity of real environments. Yet, of course, measurement in the real world is extremely difficult and requires an intelligent

infrastructure fitted with sensors to capture rich data and actuators to implement informed interventions.

At ILI, we have the vision to design the lighting of the future: supporting health and wellbeing, promoting performance, enriching daily experience. As Sound Lighting group we have formulated the ambition to create light conditions that help prevent seasonal affective disorder (SAD), a serious and very common condition involving loss of interest and energy, low mood, and difficulties with concentration. A solution would require intelligent, interactive and personalized, around-the-clock light/dark scenarios. We are contemplating the transformation of our own main building to a living lab. This is a particularly exciting plan, in which we hope to realize an intelligent infrastructure with an IP address for every individual light fixture, resulting in a vast computing system, embedded in our physical office building: the Internet of Things – the Internet of Everthing – materialized. The applications for such an infrastructure go well beyond lighting of course. This is the digital ground Malcolm McCullough speaks of; this is context 2.0 – no longer 'merely' the passive, stable structure that binds people and activities together, but a re-active, interactive pro-active medium. Will we be able to make it that magical, enchanted place some of us dream of, or will we soon pull all the plugs, longing for a space in which walls have no ears and things are set in stone again? We will see, we will learn, but we will have to tread carefully, for this is our main building, our house, our '*nest for dreaming,* [our] *shelter for imagining*' (Bachelard, p. viii). This is our context, and as much as we shape our context, afterwards our context shapes us (paraphrasing Winston Churchill, 1943).

TU/E AS CONTEXT

I too of course, have been shaped by my context. TU/e has been my academic home since I came here as a student in medical mechanical engineering in 1987. I followed courses in every single department before I learned that my heart was where people and technology meet, in the School of Innovation Sciences. But I still appreciate having learned from all those disciplines and continue to seek collaboration with them. Naturally, the department of Built Environment is close to my heart and I especially enjoy my close and warm collaboration with the Building Lighting group of Alex Rosemann. Industrial Design, too, is a department where I have come to know many friends and close colleagues. The Intelligent Lighting Institute is an environment in which I have been able to grow that network even further, with friends in computer sciences, mathematics, physics, industrial engineering and electrical engineering. I thank all of you for the many pleasant hours we have spent together and the many insights you have shared. I thank

especially the persons who are often behind the scenes, but so crucial for the organization: Samantha, Harold, and Sagitta. Special thanks go to Emile Aarts, for being the visionary and driver behind this institute, for bringing all of us together and inspiring us and – for me personally – for the many opportunities you have given me to grow and to shine. We were a good team. Thanks also to Ingrid Heynderickx, for enthusiastically taking over the baton and making sure that our lights keep shining brightly.

The TU/e is a very special university. It is a technical world, but it is also an open, inclusive and caring community. It is not a perfect world of course, students and staff alike are pressed for time and funds. But I see an organization taking bold steps in innovation of education and now making a genuine effort to learn from its members how to support them in research and education. Working on the community initiative for the Graduate School has been especially fun and enlightening for me, thanks also to the wonderful team we had.

So I see a university aware of the importance of context: the context it provides to its students and staff, as much as the context outside the grounds of our campus. Collaboration with industry, government and the public is becoming ever more intense and ever more important. So, too, do I have a context out there. So many people at Philips I have – and have had – the pleasure of working with, so many people from the municipality of Eindhoven who have been extremely supportive, people at GGzE, brave enough to open their doors for technology, all those other partners in, for instance, the De-escalate project, partners in our new and inspiring collaboration with Van Abbe. Thank you for sharing your expertise, insights and ambitions.

Moving closer to home again, I consider myself incredibly fortunate to have been able to work in the Human Technology Interaction Group for so many years. You – current and former members – are an exceptionally warm, sharing and stimulating group, professionally and personally. I made so many good friends, friends for life I feel. Some of you – particularly the 'usual suspects' – have been there to witness me reinvent myself and you may not realize how much you helped me become the person I am today. And still today, I feel welcome and cared for – especially the secretariat of Ellen and Anita is a safe haven – I am building new friendships, and I am exploring unexpected grounds – for instance in our band. Thanks everyone for all this warmth and for never hesitating to knock on my door for lunch, even though I rarely come along. Thanks also to the people without who our group would not even be able to do much research: Martin, Jan-Roelof, and Aart.

Cees, you were the promotor of my dissertation, and have been the leader of this group for the largest part of my career. With your kind-hearted, open-minded, and patient nature you have been a quiet force behind our group and what it represents today. Chris, I admire the way you are following in his footsteps. I want to thank you and Anthonie for supporting my professorship, and the groups of Philosophy and Ethics, and Technology, Innovation and Society for being such good partners and friends in our School of Innovation Sciences.

Big thanks go to all the students I had – teaching and mentoring you has been incredibly fun and edifying for me. I want to thank also former group members I worked closely with in the past: Brian, Daan, Henk Herman, Karolien, Maurice, and Wouter; and my current super team of PhD students and copromotors: Adrie, Anne, Antal, Daniel, Femke, Indre, Ingrid, Karin, Laura, Mariska. You are the motors behind our research, providers of my daily dose of inspiration, and the cherries on top of the cake called working in academia. You are the promise of our research domain, and its future looks bright.

PERSONAL CONTEXT

But of course, the two persons who helped me grow and become the person I am today most are my parents. Pap en mam, jullie zijn de liefste, meest zorgzame mensen die ik ken. Jullie waren er altijd, met liefde en vertrouwen, en durfden me gewoon mijn gang te laten gaan. Ik prijs mezelf zo rijk dat jullie er zijn en dat ik tot op de dag van vandaag bij jullie terecht kan. Lieve zussen, Debby en Marjan, naast wie ik zo heerlijk kon opgroeien, met wie ik zoveel kon delen. Ook jullie zijn, samen met jullie geweldige mannen, nog steeds voelbaar deel van mijn warme nest. Ons voormalige drie Mäderl Haus draait nu om negen fantastische knullen, tsjonge wat een rijkdom.

Lieve Janny, lieve familie van Wijnand. Bij jullie was ik meteen welkom en thuis. Arjan en Renate, jullie zijn geweldig lieve vrienden. Anneloes, van lieve collega en kamergenoot groeide je uit tot mijn meest dierbare vriendin. We delen zoveel, wetenschap is daarvan gelukkig een verwaarloosbaar onderdeel gebleken, voor alles er omheen wil ik je niet meer missen.

En dan, onze zoons Thomas, Daan, Siem en Midas. Jullie zijn mijn alles: zo verschillend, maar stuk voor stuk het liefste, slimste, grappigste en mooiste wezen op deze aarde. Ik gloei van trots en straal van blijdschap omdat ik jullie nest mee mocht bouwen, jullie mama mag zijn, en, naar ik hoop, een belangrijk stukje context in jullie lange mooie leven.

Figure 1

A General Electric advertisement from 1925, specifically addressing women.
Source: Bijker, 1995, p.235

Maar er zijn zeldzame momenten in je leven waarop context er op geen enkele wijze toe doet. Dat alleen die ene blik, die ene aanraking telt. De voorbode van iets groots. Lieve Wijn, je bent geweldig: je humor en zorgzaamheid, je intelligentie, je muziek. We kunnen zoveel samen delen, van zoveel moois samen genieten. Maar wat ik het misschien wel het meest waardeer aan je is dat ik bij jou helemaal mag zijn, wie ik wil zijn, en dat je het dan nóg mooier vindt, wanneer ik slechts ben wat ik kan zijn. Dank je wel voor dit alles.

CLOSING WORDS

I would like to close my inaugural lecture, paraphrasing words from Rudolf Moos (1976, p.viii). He was yet another great scientist I learned about in environmental psychology, the domain closest to my heart. His words echo the essence of the message I have tried to share with you today – a plea for mutual respect and intensive collaboration between scientific disciplines, between fundamental and applied research, and for the principle of beneficence:

I believe that the study of the physical, the social and the technical environment should be synthesized.
I believe that individual experience, adaptation, adjustment and coping with environments must be emphasized.
I believe that more attention should be placed on the mechanisms by which (technological) contexts act on man and woman.
I also believe that we need an approach that is applicable to current individual and societal problems and has an explicit value orientation in that it attempts to promote the quality of human life.

Ik heb gezegd.

Toen het donker was ging het vuurvliegje aan.

De olifant keek opzij. 'Wat doe je nou?' vroeg hij verbaasd.

'Aangaan,' zei het vuurvliegje, en hij gloeide zo helder als hij kon.

'Hoe doe je dat?' vroeg de olifant nieuwsgierig.

Het vuurvliegje was even stil. Dat weet ik niet, dacht hij. Hij haalde zijn schouders op en zei: 'Tsja, hoe doe ik dat…' Hij vond dat een mooi antwoord.

'Is het moeilijk?' vroeg de olifant.

O jee, dacht het vuurvliegje, is het moeilijk… Hij was weer even stil. Ik weet het niet, dacht hij. Hij haalde opnieuw zijn schouders op en zei: 'Ach moeilijk…'
Hij vond dat een nog mooier antwoord.

De olifant fronste zijn voorhoofd en dacht: ik zou ook wel eens willen aangaan.

Hij kneep zijn ogen dicht, vouwde zijn oren op, stak zijn slurf in zijn mond en dacht heel lang na, terwijl de sterren aan de hemel flonkerden en ver weg de uil af en toe iets onverstaanbaars, maar wel heel ernstigs, riep.

Uit: *Plotseling ging de olifant aan*, Toon Tellegen, 2004.
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References

Adams, F.M., & Osgood, C.E. (1973). A cross-cultural study of the affective meanings of color. *Journal of Cross-cultural Psychology, 4*(2), 135-156.

Altman, I. (1975). *The environment and social behavior*. Monterey, CA: Brooks/Cole.

Altman, I., & Rogoff, B. (1987). World views in psychology: trait, interactional, organismic, and transactional perspectives. In: D. Stokols & I. Altman (Eds.) *Handbook of environmental psychology*, pp. 7-40. New York: Wiley.

Argyle, M., & Dean, J. (1965). Eye contact, distance, and affiliation. *Sociometry, 28*, 289-304.

Arminen, I. (2005). Social functions of location in mobile telephony. *Personal Ubiquitous Computing, 10*, 319-323.

Bachelard, G. (1964/1994). *The poetics of space*. Boston: Beacon Press.

Bailenson, J.N., Beall., A.C., Blascovich, J., Loomis, J., & Turk, M. (2005). Transformed social interaction, augmented gaze, and social influence in immersive virtual envi-ronments. *Human Communication Research, 31* (4), 511–537.

Bailenson, J.N., Blascovich, J., Beall, A.C., & Loomis, J. (2001). Equilibrium theory re-visited: Mutual gaze and personal space in virtual environments. *Presence: Teleoperators & Virtual Environments, 10* (6), 583-598.

Barker, R.G., & Wright, H.F. (1951). *One boy's day; A specimen record of behavior*. Archon Books.

Baron, R.A. (1983). The control of human aggression: A strategy based on incompatible responses. In R.G. Geen & E.I. Donnerstein (Eds.), *Aggression: Theoretical and empirical reviews*. New York: Academic Press.

Bell, P.B., Greene, T.C., Fisher, J.D., & Baum, A. (2001). *Environmental psychology*. Fifth edition. Orlando: Harcourt.

Berson, D.M., Dunn, F.A., & Takao, M. (2002). Phototransduction by retinal ganglion cells that set the circadian clock. *Science, 295*(5557), 1070-1073.

Beute, F. & de Kort, Y.A.W. (2013) 'Let the sun shine! Measuring explicit and implicit preference for environments differing in naturalness, weather type and lightness.' *Journal of Environmental Psychology, 36*, 162-178.

Beute, F. & de Kort, Y.A.W. (2014a) Natural resistance. Effects of exposure to nature on self-regulation, mood, and physiology in an ego-depletion paradigm. *Journal of Environmental Psychology, 40*, 167-178.

Beute, F. & de Kort, Y.A.W. (2014b). Salutogenic effects of the environment: review of health protective effects of nature and daylight. *Applied Psychology: Health and Well-Being, 6* (1), 67–95.

Bijker, W. (1995). Of bicycles, bakelites, and bulbs; Toward a theory of sociotechnical change. Cambridge: MIT Press.

Blascovich, J., & Mendes, W.B. (2000). Challenge and Threat Appraisals: The Role of Affective Cues. In I. Forgas (Ed.), *Feeling and Thinking: The Role of Affect in Social Cognition* (pp. 59–82). London, UK: Cambridge University Press.

Bryce, J.O., & Rutter, J. (2003). Gender dynamics and the social and spatial organization of computer gaming. Leisure studies, 22(1), 1-15.

Bryson, B. (2010). *At home: A short history of private life*. London: Doubleday.

Cajochen, C. (2007). Alerting effects of light. *Sleep medicine reviews, 11*(6), 453-464.

Calvert, S.L. (2005). Cognitive effects of video games. In: J. Raessens & J. Goldstein (eds.), *Handbook of Computer Game Studies*. Cambridge, MA: MIT Press, pp. 125-131.

Carver, C.S., & Scheier, M.F. (1978). Self-focusing effects of dispositional self-consciousness, mirror presence, and audience presence. *Journal of Personality and Social Psychology, 36*, 324-332.

Clark, Th.A. (2014). Excerpt from 'When the light shifts'. *Yellow & Blue*. Carcanet Press, 2014.

Czeisler, C.A. (2013). Perspective: Casting light on sleep deficiency. *Nature, 497*(7450), S13-S13.

Dawkins, R. (1998). *Unweaving the rainbow: Science, delusion and the appetite for wonder*. New York: Houghton Mifflin Company.

Deci, E.L., & Ryan, R.M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11*(4), 227-268.

Denissen, J.J., Butalid, L., Penke, L., & Van Aken, M.A. (2008). The effects of weather on daily mood: a multilevel approach. *Emotion, 8*(5), 662.

Dourish, P. (2004). What we talk about when we talk about context, Personal and *Ubiquitous Computing, 8* (1), 19-30.

Dourish, P. & Chalmers, M. (1994). Running out of space: models of information navigation. *Proceedings of the conference on Human Computer Interaction*. (Glasgow, August 1994).

Duval, S., & Wicklund, R.A. (1972). *A theory of objective self-awareness*. New York: Academic Press.

Elliot, A.J. & Maier, M.A. (2012). Color-in-context theory. *Advances in Experimental Social Psychology, 45*, 61–126.

Elliot, A.J., & Maier, M.A. (2014). Color psychology: Effects of perceiving color on psychological functioning in humans. *Annual Review of Psychology, 65*, 95-120.

Enns, J.T., Austen, E.L., Di Lollo, V., Rauschenberger, R., & Yantis, S. (2001). New objects dominate luminance transients in attentional capture. *Journal of Experimental Psychology: Human Perception & Performance, 27*, 1287-1302.

Festinger, L.A., Schachter, S., & Back, K. (1950). *Social pressures in informal groups*. New York: Harper.

Flanagan, R. (2014). *The narrow road to the deep north*. London: Chatto & Windus.

Fleming, R., Baum, A., & Singer, J.F. (1985). Social support and the physical environment. In S. Cohen & L.S. Syme (Eds.), *Social support and health*, pp. 327-344. Orlando: Academic Press.

Franconeri, S.L., & Simons, S.D. (2003). Moving and looming stimuli capture attention. *Perception & Psychophysics, 65* (7), 999-1010.

Fredrickson, B.L., & Joiner, T. (2002). Positive emotions trigger upward spirals toward emotional well-being. *Psychological Science, 13*(2), 172-175.

Freeberg, E. (2015). *The age of Edison: Electric light and the invention of modern America*. New York: Penguin.

Gajadhar, B.J, de Kort, Y A.W., & IJsselsteijn, W.A. (2009). Rules of engagement: influence of co-player presence on player involvement in digital games. *International Journal of Gaming and Computer-Mediated Simulations, 1*(3), 14-27.

Gajadhar, B.J., de Kort, Y.A.W., & IJsselsteijn, W.A. (2011). Rules of engagement: The presence of a co-player does not hinder gamers' focus. In R. Ferdig (Ed.): *Discoveries in gaming and computer-mediated simulations: New interdisciplinary applications*. IGI Global: Hershey, Pennsylvania.

Gallagher, W. (2007). *The power of place: How our surroundings shape our thoughts, emotions, and actions*. New York: Harper Perennial.

Gergen, K.J., Gergen, M.M., Barton, W.H. (1973). *Psychology Today*, October, 129-130

Goffman, E. (1956). *The presentation of self in everyday life*. New York: Anchor Books.

Goffman, E. (1961). *Encounters; Two studies in the sociology of interaction*. Reprint 1972, Middlesex: Penguin University Books.

Goffman, E. (1963). *Behaviour in public places*. Connecticut: Greenwood Press.

Goffman, E. (1967). *Interaction ritual; Essays in face-to-face behavior*. Chicago: Aldine Pub.

Gregory, R.L. (1998). *Eye and brain. The psychology of seeing*. 5th edition. Oxford University Press.

Grillon, C., Pellowski, M., Merikangas, K.R., & Davis, M. (1997). Darkness facilitates acoustic startle reflex in humans. *Biological Psychiatry, 42*, 453-460.

Gunter, B. (2005). Psychological effects of video games. In: J. Raessens & J. Goldstein (eds.), *Handbook of Computer Game Studies*. Cambridge, MA: MIT Press, pp. 145-160.

Haans, A., & de Kort, Y.A. (2012). Light distribution in dynamic street lighting: Two experimental studies on its effects on perceived safety, prospect, concealment, and escape. *Journal of Environmental Psychology, 32*(4), 342-352.

Hall, E.T. (1959). *The silent language*. New York: Doubleday.

Hall, E.T. (1966). *The hidden dimension*. New York: Doubleday.

Hattar, S., Liao, H.W., Takao, M., Berson, D.M., & Yau, K.W. (2002). Melanopsin-containing retinal ganglion cells: architecture, projections, and intrinsic photosensitivity. *Science, 295*(5557), 1065-1070.

Hillier, B., & Hanson, J. (1984). *The social logic of space*. Cambridge: Cambridge University Press.

Hoyt, C.L., Blascovich, J., & Swinth, K.R. (2003). Social inhibition in immersive virtual environments. *Presence: Teleoperators & Virtual Environments, 12* (2), 183-195.

Huiberts, L.M., Smolders, K.C.H.J., & de Kort, Y.A.W. (2015). Shining light on memory: Effects of bright light on working memory performance. *Behavioural Brain Research, 294*, 234-245.

Isen, A.M. (1984). Toward understanding the role of affect in cognition. In R. Wyer & T. Srul (Eds.), *Handbook of social cognition*. Hillsdale, NJ: Erlbaum.

Isen, A.M. (1987). Positive affect, cognitive processes, and social behavior. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 20, pp. 203-253). New York: Academic Press.

Janssen, J.H., Bailenson, J.N., Ijsselsteijn, W., & Westerink, J.H. (2010). Intimate heartbeats: Opportunities for affective communication technology. *Affective Computing, IEEE Transactions on, 1*(2), 72-80.

Jeffrey, P., & Mark, G. (1998). Constructing social spaces in virtual environments: A study of navigation and interaction. In: K. Höök, A. Munro, & D. Benyon (Eds.): *Workshop on personalised and social navigation in information space*, March 16-17, 1998, Stockholm: Swedish Institute of Computer Science (SICS), 24-38.

Kaida, K., Takahashi, M., & Otsuka, Y. (2007). A short nap and natural bright light exposure improve positive mood status. *Industrial Health, 45*(2), 301-308.

Kaplan, R., & Kaplan, S. (1989). *The experience of nature: A psychological perspective*. CUP Archive.

Kjeldskov, J., & Paay, J. (2005, September). Just-for-us: a context-aware mobile information system facilitating sociality. In *Proceedings of the 7th international conference on Human computer interaction with mobile devices & services* (pp. 23-30). ACM.

Knez, I. (2001). Effects of colour of light on nonvisual psychological processes. *Journal of Environmental Psychology, 21*, 201–208.

de Kort, Y.A., & IJsselsteijn, W.A. (2008). People, places, and play: Player experience in a socio-spatial context. *ACM Computers in Entertainment (CIE), 6*(2), 18:1-11.

de Kort, Y.A. W., IJsselsteijn, W.A., Haans, A., Lakens, D., Kalinauskaite, I., & Schietecat, A. De-escalate: Defusing escalating behaviour through the use of interactive light scenarios. *EXPERIENCING LIGHT 2014*, 94.

de Kort, Y.A. W., Meijnders, A.L., Sponselee, A.A.G., & IJsselsteijn, W.A. (2006). What's wrong with virtual trees? Restoring from stress in a mediated environment. *Journal of Environmental Psychology, 26*(4), 309-320.

de Kort, Y.A.W. & Veitch, J.A. (2014). From blind spot into the spotlight. *Journal of Environmental Psychology, 39*, 1-4.

Kuijsters, A., Redi, J., de Ruyter, B., & Heynderickx, I. (2015). Lighting to Make You Feel Better: Improving the Mood of Elderly People with Affective Ambiences. *PloS One, 10*(7), e0132732.

Küller, R., Ballal, S., Laike, T., Mikellides, B., & Tonello, G. (2006). The impact of light and color on psychological mood: A cross-cultural study of indoor work environments. *Ergonomics, 49*, 1496- 1507.

Lakens, D., Semin, G.R., & Foroni, F. (2012). But for the bad, there would not be good: Grounding valence in brightness through shared relational structures. *Journal of Experimental Psychology: General, 141*(3), 584.

Laurier, E. (2001). Why people say where they are during mobile phone calls. *Environment and Planning D: Society and Space, 19*, 485-504.

van Lier, R. & Vergeer M.(2008). Filling in the afterimage after the image. First prize, *Illusion of the year contest 2008*. http://illusionoftheyear.com/2008/filling-in-the-afterimage-after-the-image/

Lombard, M. (1995). Direct responses to people on the screen television and personal space. *Communication Research, 22*(3), 288-324.

Lynch, K. (1960). The image of the city. Cambridge, MA: MIT Press.

Marvin, C. (1988). *When old technologies were new. Thinking about communications in the late nineteenth century*. New York: Oxford University Press.

McCullough, M. (2004). *Digital ground: Architecture, pervasive computing, and environmental knowing*, MIT Press, Cambridge, MA.

Misra, S., Cheng, L., Genevie, J., & Yuan, M. (2014). The iPhone effect the quality of in-person social interactions in the presence of mobile devices. *Environment and Behavior*, published online before print, doi: 10.1177/0013916514539755.

Munro, A., Höök, K., & Benyon, D. (1999). Footprints in the snow. In A. Munro, K. Höök, & D. Benyon (Eds.): *Social navigation of information space*, pages 1-14. London: Springer.

Osgood, C.E., & Richards, M.M. (1973). From yang and yin to and or but. *Language*, 380-412.

Osmond, H. (1957). Function as a basis of psychiatric ward design. *Mental Hospitals, 8*, 23-29.

Page, R.A., & Moss, M.K. (1976). Environmental influences on aggression: The effects of darkness and proximity of victim. *Journal of Applied Social Psychology, 6*, 126-133

Poels, K., de Kort, Y.A.W., & IJselsteijn, W.A. (2007). "It is always a lot of fun!" Exploring dimensions of digital game experience using focus group methodology, *Proceedings of Futureplay 2007* (Toronto, Canada), pp. 83-89

Pressman, S.D., & Cohen, S. (2005). Does positive affect influence health?. *Psychological Bulletin, 131*(6), 925.

Proshansky, H.M., Ittelson, W.H., & Rivlin, L.G. (1976). *Environmental psychology: People and their physical settings*, 2nd edition. New York: Holt, Rinehart and Winston.

Rijswijk, L. van (2016). *Shedding light on appraisals of environmental safety*. Eindhoven University of Technology: Doctoral dissertation.

Roenneberg, T. (2012). *Internal time. Chronotypes, social jet lag, and why you're so tired*. Cambridge: Harvard University Press.

Rose, D. (2014). *Enchanted Objects: Innovation, design, and the future of technology*. New York: Scribner.

Aan Het Rot, M., Moskowitz, D.S., & Young, S.N. (2008). Exposure to bright light is associated with positive social interaction and good mood over short time periods: A naturalistic study in mildly seasonal people. *Journal of Psychiatric Research, 42*(4), 311-319.

Sahin, L., & Figueiro, M.G. (2013). Alerting effects of short-wavelength (blue) and long-wavelength (red) lights in the afternoon. *Physiology & behavior, 116*, 1-7.

Schmidt, A., Takalouma, A., & Mäntyjärvi, J. (2000). Context-aware telephony over WAP. *Personal Technologies, 4*, 225-229.

Skjaeveland, O. & Gärling, T. (1997). Effects of interactional space on neighbouring. *Journal of Environmental Psychology, 17*, 181-198.

Smolders, K.C.H.J. & de Kort, Y.A.W. (manuscript submitted for publication). *Exploring daytime effects of correlated colour temperature on alertness and vitality*: Results on self-report, task performance and physiological arousal.

Smolders, K.C.H.J., de Kort, Y.A.W. & van den Berg, S. (2013). Daytime light exposure and feelings of vitality: Results of a field study during regular weekdays. *Journal of Environmental Psychology, 36*, 270-279.

Smolders, K.C.H.J., de Kort, Y.A.W. & Cluitmans, P.J.M. (2015). A higher illuminance induces alertness even during office hours: findings on EEG measures. *Lighting Research & Technology*, in press.

Smolders, K.C.H.J., de Kort, Y.A.W. & Cluitmans, P.J.M. (2012). A higher illuminance induces alertness even during office hours: findings on subjective measures, task performance and heart rate measures. *Physiology & Behavior, 107*, 7-16.

Sommer, R. (1967). Small group ecology. *Psychological Bulletin, 67*, 145-152.

Sommer, R. (1959). Studies in personal space. *Sociometry, 22*, 247-260.

Sommer, R. (1961). Leadership and group geography. *Sociometry, 24*, 99-110.

Sommer, R., Herrick, J., & Sommer, T.R. (1981). The behavioral ecology of supermarkets and farmers' markets. *Journal of Environmental Psychology, 1*, 13-19.

Sommers, S. (2011). *Situations matter: Understanding how context transforms your world*. Penguin.

Steidle, A., & Werth, L. (2014). In the spotlight: Brightness increases self-awareness and reflective self-regulation. *Journal of Environmental Psychology, 39*, 40-50.

Steidle, A., Hanke, E.-V., & Werth, L. (2013). In the dark we cooperate: The situated nature of procedural embodiment. *Social Cognition: Vol. 31, Situated Social Cognition*, pp. 275-300.

Tamminen, S., Oulasvirta, A., Toiskallio, K., Kankainen, A. (2003). Understanding mobile contexts. In *Proceedings of MobileHCI 2003*, 17-31. Udine, Italy: Springer.

Tellegen, T. & van Haeringen, A. (2004). Plotseling ging de olifant aan. Amsterdam: Querido.

Ulrich, R.S. (1983). Aesthetic and affective response to natural environment. In *Behavior and the natural environment* (pp. 85-125). Springer US.

Vandewalle, G., Balteau, E., Phillips, C., Degueldre, C., Moreau, V., Sterpenich, V., ... & Maquet, P. (2006). Daytime light exposure dynamically enhances brain responses. *Current Biology, 16*(16), 1616-1621.

Vandewalle, G., Gais, S., Schabus, M., Balteau, E., Carrier, J., Darsaud, A., ... & Maquet, P. (2007). Wavelength-dependent modulation of brain responses to a working memory task by daytime light exposure. *Cerebral Cortex, 17*(12), 2788-2795.

Vandewalle, G., Maquet, P., and Dijk, D.J. (2009). Light as a modulator of cognitive brain function. *Trends in Cognitive Science, 13*, 429–438.

Veitch, J.A., Stokkermans, M.G., & Newsham, G.R. (2013). Linking lighting appraisals to work behaviors. *Environment and Behavior, 45*(2), 198-214.

Vogels, I. (2009). How to make life more colorful: from image quality to atmosphere experience. *Seventeenth Color Imaging Conference: Color Science and Engineering Systems, Technologies, and Applications*, 123-128, Albuquerque, NM.

Vyzoviti, S. (2005). *Emergent places for urban groups without a place; Representation, explanation, prescription*. Dissertation, Delft: Technische Universiteit Delft.

Wapner, S., & Demick, J. (2002). The increasing contexts of context in the study of environment-behavior relations. In: R.B. Bechtel, & A. Churchman: *Handbook of Environmental Psychology*, Chapter 1, pp. 3-14. New York: John Wiley & Sons.

Weilenmann, A. (2003). "I can't talk now, I'm in a fitting room": Availability and Location in Mobile Phone Conversations. *Environment and Planning A, special issue on Mobile Technologies and Space*, E. Laurier (Ed.), 35 (9), 1589 – 1605.

Weiser, M. (1991). The computer for the 21st century. *Scientific American, 265*(3), 94-104.

Werner, C.M., Brown, B.B., & Altman, I. (2002). Transactionally oriented research: Examples and strategies. In: R. B. Bechtel, & A. Churchman: *Handbook of Environmental Psychology*, Chapter 1, pp. 3-14. New York: John Wiley & Sons.

Whyte, W.H. (1980). *The social life of small urban spaces*. Washington DC: Conservation Foundation.

Williams, B. (1999). *Stage Lighting Design*; Edition 2; PART 1 - An Introduction to Stage Lighting; http://www.mts.net/~william5/sld/sld-100.htm

Zeisel, J. (1981). *Inquiry by design. Tools for Environment-behavior research*. Cambridge University Press.

Zhong, C.-B., Bohns, V.K., & Gino, F. (2010). Good lamps are the best police. Darkness increases dishonesty and self-interested behavior. *Psychological Science, 21*(3), 311–314.

Curriculum Vitae

Prof. Yvonne de Kort was appointed full-time professor on the Contextual perspective in Human-Technology Interaction at the Department of Industrial Engineering and Innovation Sciences on January 1, 2015.

Yvonne de Kort (1969) graduated at TU/e in what is now called Human-Technology Interaction (HTI). As an environmental psychologist in a technical university, her research focuses on the intersection between spaces, technology and human experience. The core of this research is in the effects of light and natural views on human functioning, a field that requires combining insights from lighting technology, perception studies, social and environmental psychology, biology and neuroscience. Around this theme she has established her own research program within HTI. Yvonne is also the program manager for 'Sound Lighting', an interdisciplinary program line within TU/e's Intelligent Lighting Institute (ILI). Yvonne participated in numerous commercial, national and European projects. She currently leads the NWO-funded project De-escalate, and is topic owner Health and Wellbeing in the Impulse research program Engineering Natural Lighting solutions in the Philips-TU/e lighting flagship.

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