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Adaptivt lys / Adaptive Lighting

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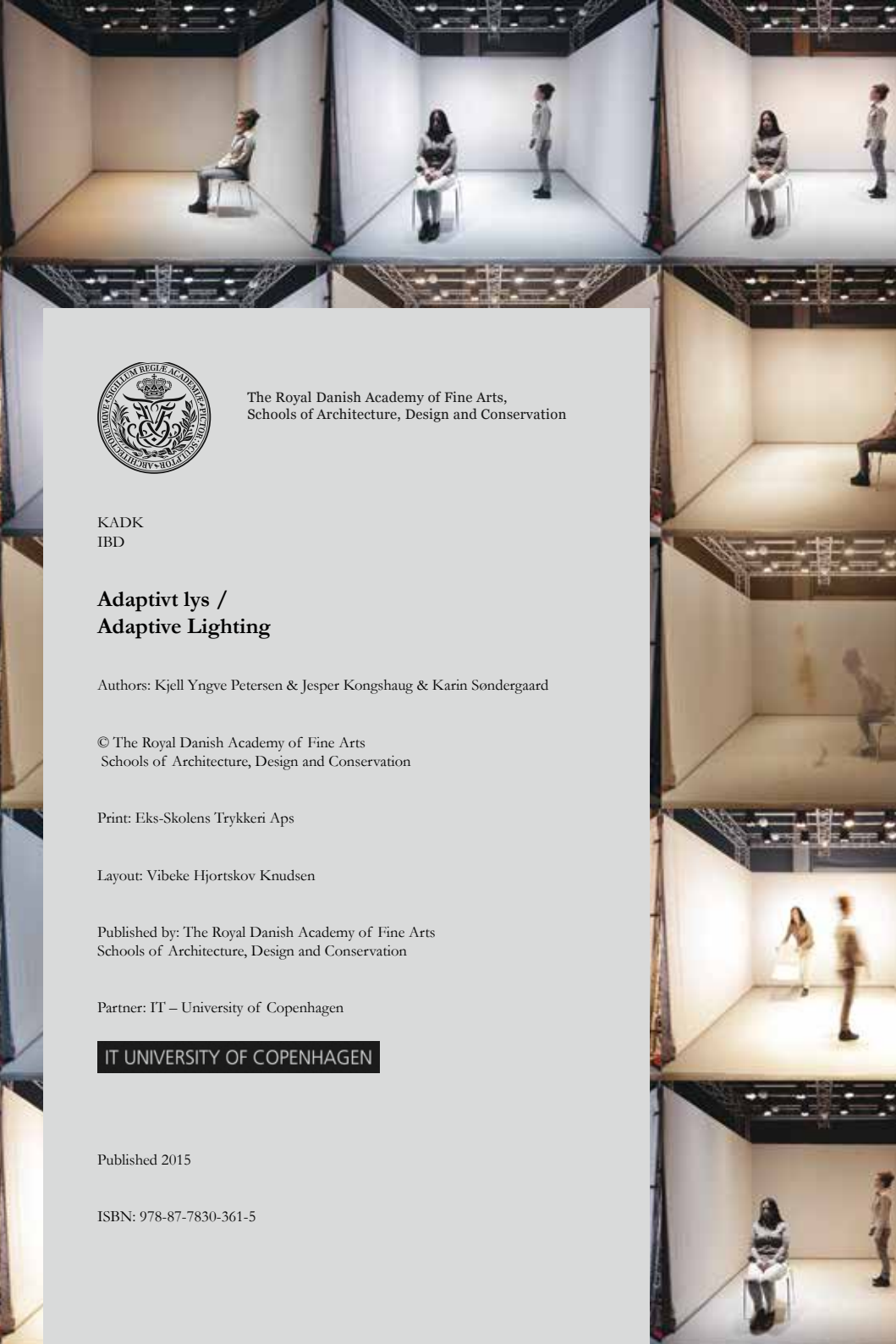
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Adaptivt lys

Adaptive Lighting

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Forord

Denne bog er en af fire bøger udgivet i forbindelse med forskningsprojektet *LEDlys; Interdisciplinær LED lysforskning*. Forskningsprojektet har været et treårigt samarbejde mellem Det Kongelige Danske Kunstakademis Skoler for Arkitektur, Design og Konservering, og IT-Universitetet i København.

Med LED-lyskilden (Light Emitting Diode) er der introduceret afgørende nye betingelser for belysningsområdet. Hvor lyskilder tidligere var konstante størrelser med fast definerede lysfarver og lysintensiteter, lancerer LED teknologien helt nye potentialer, hvor det er muligt at operere med komplekse forandringer af farvekvaliteter og lysintensiteter. LED er desuden konvertibel til digitale styringssystemer, hvilket betyder, at en betydelig del af designudviklingen i fremtiden vil foregå som software-design, og at kunstlyset fremover vil være potentielt dynamisk, intelligent og adaptivt. På grund af LEDens meget lille størrelse er der mange muligheder for integrering af lyskilder i materialer, bygningstrukturer og byrum. Alle disse forhold har stor indflydelse på udformningen af fremtidens design, arkitektur og IT infrastruktur. Der er derfor et udstrakt behov for nyudvikling af begrebslige defineringer, udvikling af planlægnings-strategier, og der er i høj grad brug for en udforskning og identificering af nye æstetiske og kvalitative parametre i relation til LED. Projektet inddrager disse komplekse sammenhænge ud fra en særlig fokus på perceptuelle oplevelsesparametre som organiserende design-princip.

Forskningsprojektet er opdelt i følgende tre skala områder:

Mikro skala, – hvor LEDen er forstået og undersøgt som del af et pixel system. Projektet udforsker hvilke kvaliteter LEDen potentielt tilfører belysningsapplikationer i arkitektonisk kontekst. Publikationen, *Pixel Eksperimenter*, beskriver udførte eksperimenter og hvordan erfaringer fra disse test opstillinger danner mulige strategier for design af belysningsapplikationer med LED.

Medium skala, – med en fokus på det arkitektoniske rum som lysarmatur. Disse praksis-baserede undersøgelser er opdelt i to foki. Den ene handler om integrering af dagslys og dynamisk kunstlys, som udfoldes i bogen *Integration af dagslys og dynamisk kunstlys undersøgt gennem et iagttagelsesinstrument*. Den anden – handler om undersøgelsen af rummet som lysende armatur og adaptive lyssituationer i test installationer. Undersøgelserne analyseres og diskuteres i bogen *Adaptivt lys*.

Makro skala, – med LEDlys som ny belysningskomponent i byrummet. Projektet arbejder med en mapping metode, hvormed byens oplevede belysning anskueliggøres i relation til den overordnede planlægning af gadebelysning. Projektet anvender København som case. Metoden belyses i bogen *På tværs af Københavns Gadebelysning 2014*.

I denne bog diskuteres undersøgelserne af lysscenerier foretaget i to test installationer: *White Cube*, og *White Box*. Test installationerne diskuteres som oplevelsesinstrumenter i stor skala. I disse test installationer undersøger vi, hvad der potentielt sker, når lyset med LED teknologien bliver integreret og fordelt anderledes i den arkitektoniske krop, – når lyset bliver dynamisk og kan skifte i farve, intensitet og retning, og når det bliver adaptivt og kan bringes i interaktion med omgivelserne. Kort sagt, hvad sker der med rummet, når kunstlyset ophører med at være statisk, og ikke længere som en slags rumlig *konstans* opretholder stabilitet og orden? Og hvilke nye potentialer åbnes for i lysdesignet?

I forbindelse med oplevelsesanalyserne vil vi gerne takke Brian Wendin, Katja Bülow, Christina Augustesen og Karina Mose for deres deltagelse i oplevelses-interviews. Disse interviews har hjulpet os i udredningen af problematikker, – af nye potentialer betinget af led teknologien, samt i de kvalitative vurderinger af de forskellige lyssituationer.

Karin Søndergaard

Preface

This book is one of four books that is published in connection with the research project entitled *LED Lighting: Interdisciplinary LED Lighting Research*. The research project has been a three-year collaboration between The Royal Danish Academy of Fine Arts; Schools of Architecture, Design and Conservation and The IT University of Copenhagen.

The LED (Light Emitting Diode) light source has introduced new, crucial conditions to the field of lighting design. Where light sources have previously been of uniform sizes with predefined colour temperatures and luminous intensities, LED technology brings forth totally new potentials, where it is possible to operate with complex changes in colourations and luminous intensities. LEDs are moreover convertible to digital control systems, which mean that a significant part of design developments in the future will occur in the form of software design, and that artificial lighting will continue to be potentially dynamic, intelligent, and adaptive. Because LEDs have a very small size, there are many opportunities for their integration into materials, building structures, as well as urban spaces. All these factors exert major influences on the shaping of future design, architecture, and IT infrastructure. Therefore, there exists an extensive need for new developments in conceptual delineations, the development of planning strategies, and – to an especially high degree – an exploration and identification of new aesthetic and qualitative parameters related to LEDs. This project engages these complex contexts and concerns via a specific focus on perceptual experiential parameters as an organising design principle.

The research project is divided into the following three areas of scale:

Micro scale, wherein LEDs are understood and studied as part of a pixel system. This project explores the qualities that LEDs can potentially add to lighting applications in architectural contexts. This publication, *Pixel Experiments*, describes executed experiments and how the lessons learned from these test setups form possible strategies for the design of lighting applications using LED

Mezzo scale, with a focus on architectural space as a luminaire. These practice-based studies are divided into two foci. One concerns the integration of dynamic artificial lighting and daylight, which is unfolded in the book called *An Exploration Into Integrating Daylight and Artificial Light via an Observational Instrument*. The second is about an inquiry of space as a luminous luminaire, as well as adaptive lighting situations in test installations. The studies are analysed and discussed in the book entitled *Adaptive Lighting*.

Macro scale, with LED lighting as a new lighting component in urban spaces. This project works with a mapping method in which the lighting experienced in the city is visualised in relation to the overall planning of the street lighting. The project uses Copenhagen as a case study. The method is illustrated in the book *Into a Mapping of Copenhagen Street Lighting 2014*.

This book discusses the investigations of lighting scenarios carried out in two test installations: *White Cube* and *White Box*. The test installations are discussed as large-scale experiential instruments. In these test installations we examine what could potentially occur when light using LED technology is integrated and distributed differently into an architectural body. We also examine what might occur when light is dynamic and able to change colour, intensity and direction, and when it is adaptive and can be brought into interaction with its surroundings. In short, what happens to an architectural space when artificial lighting ceases to be static, and no longer acts as a kind of spatial *constancy* maintaining stability and order? Moreover, what new potentials open in lighting design?

In connection with the experiential analyses we would like to thank Brian Wendin, Katja Bülow, Christina Augustesen, and Karina Mose for their participation in the experiential interviews. These interviews helped us in representing the challenges and conditions related to the new potentials conditioned by LED technology and the qualitative assessments of the various lighting situations.

Karin Søndergaard

Adaptivt lys
Adaptive Lighting

LED lyskilder og adaptivt lysdesign

LED teknologien introducerer en fremtidig belysningssteknologi, der på ganske afgørende måder og i flere henseender indebærer nye potentialer indenfor arkitektonisk belysningsdesign. I modsætning til tidligere lyskilder er der med LED tale om en konvertibel digital komponent, der løbende kan modtage og afspille data og således indgå i større komplekse styringer, hvor det er muligt at operere med lysfarve og lysintensitet i dynamiske flow. Med LED lyskilden bevæger kunstlyset sig potentielt fra at være en *konstans*, – altså en rumlig kvalitet der etablerer fasthed i oplevelsen af den rumlige omgivelse, til at være en dynamisk interagerende størrelse, der, i lighed med det omskiftelige og dynamiske dagslys, har fluktuerende egenskaber.

De hidtidige mere statiske lyskilder har netop som følge af en teknologiske begrænsning opretholdt og bidraget til en rumlig *konstans*. Man kan sige, at med det hidtidige kunstlys statiske belysning i henhold til farve og intensitet, samt de relativt få lyskilders installationer i fast placerede lamper og lysarmaturer, har belysningen i det elektriske lys historie opbejlet en belysningsmæssig rumlig *konstans*, som vi har vænnet os til, og som nu udfordres af LED.

LED er en lyskilde, som på mange måder bryder grænserne for hidtidig armaturdesign. Tidligere lyskilder var begrænsede som singulært lysende objekter med hver sin indbygning, og den punktformede lyskilde er med LED teknologien bredt ud på mange mindre og forbundne lyskilder. De enkelte dele af et lysdesign med LED er potentielt styrbare og derfor individuelt dynamiske, og hver diode kan have indbygget flere lyskarakteristika og være grupperet i varierede mønstre af sammenhænge. Denne øgede variationsmulighed og ofte stærkt øgede mængde af lysgivere åbner for en helt nye kompleksiteter indenfor lysdesign med variationer i den samme installation, og med muligheder for lokal dynamisk tilpasning og involvering af komplekse styringsscenarier til individuelle eller kollektive behov indenfor en givet arkitektonisk kontekst.

LED'en er tillige en lille og implementerbar størrelse, der let lader sig integrere i forskellige arkitektoniske formgreb, og i et fremtidigt scenarie vil fremstillingsprocessen af rumlige elementer logisk indeholde integration af LED lyskilder.

I den traditionelle belysningsopfattelse er lyskilden betragtet som en appendiks til rummet, og et lysdesign besluttet kun i nogen grad ud fra rummets udformning, – lyset monteres i rummet efter dette er færdigt, hvor lyskilder placeres på vægge eller ophængt fra loft som pendel eller armatur.

Med LED teknologien kan lyset integreres i den arkitektoniske bygningskrop, således rummet i sig selv kommer til at fungere som et lysende armatur. Samtidig arbejdes der i bygningsindustrien med nye composite materialer, dvs. flere materialer der i sammenhæng danner nye materiale kvaliteter, herunder translucente og reflekterende materialer. Dette muliggør en udvidet variation i lyskildernes rumlige implementering og placering, og det åbner for belysningsformer, der for eksempel minder om sekundære lysgivere, altså som flader af reflekteret diffust lys, – eller indstråling af skarpt rettet lys gennem designede translucente huller eller sprækker. Alt dette betyder også at design af kunstlyset i langt større grad må indtænkes i den arkitektoniske helhed og ikke, som så ofte hidtil, opstå som efterfølgende appendiks løsninger.

Set fra et socialt perspektiv hed det sig i tidligere præferencer indenfor belysning, at man samlede sig om lampen, som man førhen samlede sig om bålet eller ildstedet. Senere samlede familien sig om det lysende tv-apparat. Tv-apparatet og computerenskræmen er senere diskuteret metaforisk som et vindue ud mod verden, – den lysende skærm, der kommunikativt oplyser om verden udenfor. I og med lys bliver digital og styres af data, er det ganske nærliggende at tænke belysning ind som led i kommunikative operationer.

Også dagslysindfaldet i en bygning kan tænkes som kommunikation. De slørede camera obscura projektioner, der kanaliseres gennem vinduet ind i det interiore rum, kan som fænomen siges at være en form for visuel kommunikativ proces, hvor den nære omgivelse kommunikerer ind i rummet.

LED Light Sources and Adaptive Lighting Design

LED technology introduces a future lighting technology that involves new potentials for architectural lighting design in many regards and in quite profound ways. Unlike previous light sources, LEDs are a convertible digital component, which can continuously receive and play data and can be part of a larger complex control system within which it is possible to operate using light colours and luminous intensities in dynamic flows. Using an LED light source, artificial lighting can potentially reposition itself from being a *constancy* – that is, to being a spatial quality that establishes a fixity in the experience of a spatial environment – to being a dynamic interacting feature having characteristics resembling the fluctuations and dynamism of daylight.

The previous and more static light sources have merely followed and maintained a technological limitation and thereby contributed to spatial *constancy*. Due to the static illumination of the current artificial lighting in terms of colour and intensity, as well as to the fact that the installations of these light sources are fixed in lamps and luminaires, one can say that illumination with regards to the history of electric lighting has received a lighting-related spatial *constancy* which we have become accustomed to – and which is now being challenged by LEDs.

LEDs are a light source that break the boundaries of existing luminaire designs in several ways. Former light sources were limited; being singular luminous objects, each with their own fixed installation. With LED technology, the previous single-point light source now spreads out to become several smaller, associated light sources. Furthermore, the individual parts of an LED lighting design are potentially controllable and therefore also potentially dynamic on an individual level. Each diode may have multiple lighting characteristics built into it, and multiple diodes can be grouped into varied patterns of correlations. This increased variability coupled together with the often highly increased number of light sources opens up entirely new complexities and possibilities in lighting design; including variations within the same installation, opportunities for local dynamic adaptation, and the involvement of complex control scenarios based on the individual and/or collective needs of a given architectural context.

The LED light source is also of such a small and implementable size that it is easily integrated into diverse architectural conceptions and forms. And in future scenarios, the manufacturing processes of spatial elements will logically include the integration of LED light sources.

In a traditional view on lighting, a light source is considered as an appendage to a space, and a lighting design is only decided upon to some degree based upon the design of the space – i.e. the lighting is installed in a space after the space is completed, wherein the light sources are mounted on the walls and/or suspended from the ceiling as pendants and luminaires.

Using LED technology, light can now be integrated into the architectural body of a building, such that the architectural space itself can act as a luminous luminaire. At the same time, in the building industry, work is already being undertaken using new composite materials; that is, multiple materials that together form new material qualities and include translucent and reflective materials. This allows for an extended variation in the spatial implementation and placement of light sources. It likewise opens potentials for emitting light in ways that are, for example, reminiscent of secondary light sources, such as surfaces of reflected diffuse light or of the flow of sharp directed light flowing through designed translucent openings or fissures. All this also means that the design of artificial lighting should be incorporated into an architectural whole to a much greater degree – and not, as so often afore, occurring as subsequent appended solutions.

From a social perspective, previous preferences within lighting design have advocated for the view of people gathering around a lamp, just as people prior to electric lighting gathered around a campfire or fireplace. More recently, families can be seen to gather around the glow of the television set instead. The television, and later computer screens, gained the metaphorical designation of being a window onto the world: the luminous screens that communicatively inform one about the wider world. As light becomes digital and controlled by data, it becomes all the more possible to think about lighting in the context of communicative operations.

Man må forvente lysdesignet i fremtiden vil anvende live streaming af data og være responsiv i forhold til bestemte værdier, der registreres gennem dertil bestemte sensors. Man må forvente, at fremtidens beboere af adaptive bygninger vil interagere med og i lysforhold, der er dynamiske, dvs. har en tidsdimension, og således er foranderlig over tid, – og som er responsiv i relation til ønsker og behov.

Indtil for nylig har det elektriske kunstlys som nævnt haft en statisk karakter med faste mål i farvetemperaturer og lysintensitet, og der har været relativ færre og singulært installerede lyskilder. I oplevelsen af et kunstigt belyst rum har man således orienteret sig ved en belysningsmæssig konstans, hvor tingenes fremtræden, lyset og skyggerne, fordelingen af lysrum og mørkerum (Madsen 2002) har været statiske og forudsigelige. Når mennesker bevæger sig i disse statisk belyste rum, kan man stole på at lyset, ligesom rummet og tingene i rummet etablerer en konstans, hvor det i rumoplevelsen udelukkende er mennesket i rummet, der udgør et dynamisk aspekt.

Med LED indføres det nye adaptive lysdesign, hvor forholdet mellem menneske og rum åbnes for kontinuerlig tilpasning. I selve rumoplevelsen engageres mennesket i en responsiv forhandling omkring den arkitektoniske fremtræden, hvor de nye adaptive forhold potentielt afstedkommer en kontinuerligt udvekslende engagement mellem mennesket og lyset i rummet.

I denne designbaserede forskning har vi udviklet to installationer, hvor vi kan fokusere på oplevelsesmæssige problematikker i forhold til de adaptive potentialer i LED-teknologien.

The daylight entering into a building can also be thought of as a form of communication; the blurry camera obscura projections being channelled through a window into an interior space. This phenomenon can be seen to be a kind of visual communicative process in which the immediate exterior surroundings are communicated into an interior space.

One must expect that lighting design in the future will use livestream data and be responsive relative to the specific values being recorded by sensors. One must moreover expect that the future residents of adaptive buildings will interact with, and in, lighting conditions that are dynamic – meaning that they have a temporal dimension and are thus changing over time, allowing them to be responsive in relation to people's wishes and needs.

As previously mentioned, artificial lighting has, until recently, possessed a static character with fixities in terms of colour temperature and luminous intensity. Additionally, these former light sources have been relatively fewer in number and installed as separate single-point light sources. Experiencing an artificially illuminated architectural space of this sort, one thus orients themselves according to a lighting constancy, where the appearance of things, light and shadows, and the distribution of light-zones and dark-zones (Madsen 2002) are static and predictable. When people move about in such statically illuminated spaces, one can rely on the light, just as with the space and the things in the space, to establish constancy. And in such conditions, it is only the people in the space who account for dynamic aspects.

Along with LEDs comes the introduction of new adaptive lighting design, where the relationship between people and architectural space opens up to possibilities of continual adaptation. In the spatial experience itself, one is engaged in a responsive negotiation about architectural appearance, where the new adaptive conditions can potentially lead to a continuously exchanging engagement between people and the light in a given space.

In this design-based research, we have developed two installations with which we could focus on experiential issues in relation to the adaptive potentials of LED technology.

Oplevelsesinstrumenterne Experiential Instruments





Oplevelsesinstallationerne

De to installationer er iscenesatte oplevelses-rum. White Cube installationen (s. 17, 21, 22) er en hvid kube af projektionsfolie belyst udefra på alle flader inklusive gulv og loft. White Box installationen (s. 16) er et scenografisk rum med hvide vægge belyst bagfra og en grid af downlights. Rummene er tomme og fremstår som hvide testomgivelser uden nogen yderligere indretning. Rummene skal servicere oplevelses-undersøgelser af dynamisk foranderlige lysdesign med forskellige rumlige kompositioner af lysfarver og intensiteter.

Installationerne fungerer som prototyper for design af mulige lyssætninger, og samtlige lyskilder i installationerne er koblet til styrings-systemer med specialdesignet software, således installationerne i hurtige skift kan iscenesætte forskellige lysdesign. Installationerne beforder hver sin specifikke oplevelsessituation, hvor man i hurtige flows kan forandre lysdesignet og i sammenlignede analyser diskutere lysescesættelser i et forhold til hinanden.

Undersøgelserne handler som sagt ikke om statisk belysning, men retter netop sit interessefelt mod adaptive funktioner i dynamisk belysningsdesign, hvor belysningsdesignet vil interagere med bevægelser i rummet. Installationerne er således indrettet som mulighedsrum for at kunne kvalificere forholdet mellem mennesket, der opholder og bevæger sig i rummet, og de potentielle dynamiske tilpasninger af lysdesignet.

I installationerne kan vi undersøge det potentielle i fremtidige automatiserede dynamiske lysdesign. Hvilke oplevelsesmæssige konsekvenser medfører det, hvis lysdesignet tilpasser sig personlige lyspræferencer, og hvilke forhandlinger vil der i så fald skulle foregå imellem de individuelle ønsker, det rumlige lysdesign og den arkitektoniske indretning?

De to installationer er indrettet som performative scenografier, – eller explorative installationer, der iscenesætter forskellige aspekter af oplevelser i en fremtidig adaptiv lysdesign. Der iscenesættes således en række lyssituationer med dynamiske forandringer af farvebalancer og lysniveauer som afstedkommer specifikke muligheder for at følge personers bevægelser i rummene.

Lyskilderne i White Cube installationen er bygget af elementer fra stor-skærms LED paneler, som belyser den hvide projektionsdug udefra fra alle sider. Styringssoftwaren afspiller animeret grafik i fuldt farvespekter, med muligheder for direkte indstilling af variationer i lysets design og dynamik.

White Box installationen har en avanceret styring af rummets lysdynamik, med basis i en grid af 16 lyskilder fra oven med rettet lodret belysning, og bagbelyste sider der afgiver diffust vandret lys. Alle lyskilder kan individuelt varieres i lysfarve og lysintensitet. Softwaren giver mulighed for at styre lysdesignet direkte i dynamik og komposition, og kan genspille scenarier af pre-designede lyskompositioner. Softwaren kan definere en afgrænset del af lyskilderne som følgespot, hvorved lys eller mørke kan styres til at følge personers bevægelser i installationen.

The Experiential Installations

The two installations are staged as experiential spaces. White Cube (p 17, 21 and 22) is a cube made of projection screens illuminated on all surfaces, including the floor and ceiling. White Box (p 16) is a scenographic space with back-lit white walls and a grid of downlights. Both spaces are empty and appear as white testing environments without any added furnishings or interior design. The spaces support experiential investigations of dynamically changing lighting designs with differing spatial compositions of light colours and luminous intensities.

The installations function as prototypes for the design of possible lighting settings. All the light sources in the installations are coupled to control systems using custom designed software, such that the installations can orchestrate different lighting designs in rapid shifts. The installations each stage their own particular experiential space, wherein one can change the lighting design in fast flows and discuss the lighting stagings in relation to one another via comparative analyses.

As noted, the studies are not about static lighting, but instead direct their field of interest to the adaptive features of dynamic lighting design, where lighting design interacts with people's movements in a given space. The installations are accordingly arranged as spaces of possibility in order to qualify the relationship between a person being in, and moving about, an installation space and the potential dynamic adaptations of the lighting design.

In the installations, we have been able to explore the potentials of future automated dynamic lighting design. Amongst other things, we have questioned: What experiential consequences are entailed if the lighting design adapts itself to personal lighting preferences? And what negotiations should then take place between individual wishes, the spatial lighting design, and the architectural design?

The two installations are arranged as performative scenographies or explorative installations that stage various aspects of experiences in future adaptive lighting design. A number of lighting situations having dynamic changes in colour balance and light levels are staged; and with specific opportunities to follow the movements of people in the spaces.

The light sources in the White Cube installation have been created using elements of large screen LED panels, which illuminate the white projection screens from the outside and from all sides. The control software plays animated graphics in full colour spectrum, with opportunities for direct settings of variations in the lighting design and dynamics.

The White Box installation has advanced control of the space's lighting dynamics, with its base being a grid of 16 light sources positioned overhead with targeted vertical lighting, and backlit sides emitting diffuse horizontal illumination. All the light sources can be varied individually in terms of their colour temperatures and luminous intensities. The software provides the ability to directly control the lighting design's dynamics and composition, and it can also replay scenarios of pre-designed lighting compositions. Since the software can designate a defined portion of the light sources as followspots, the light and darkness can be controlled so as to follow the movements of the people inside the installation.

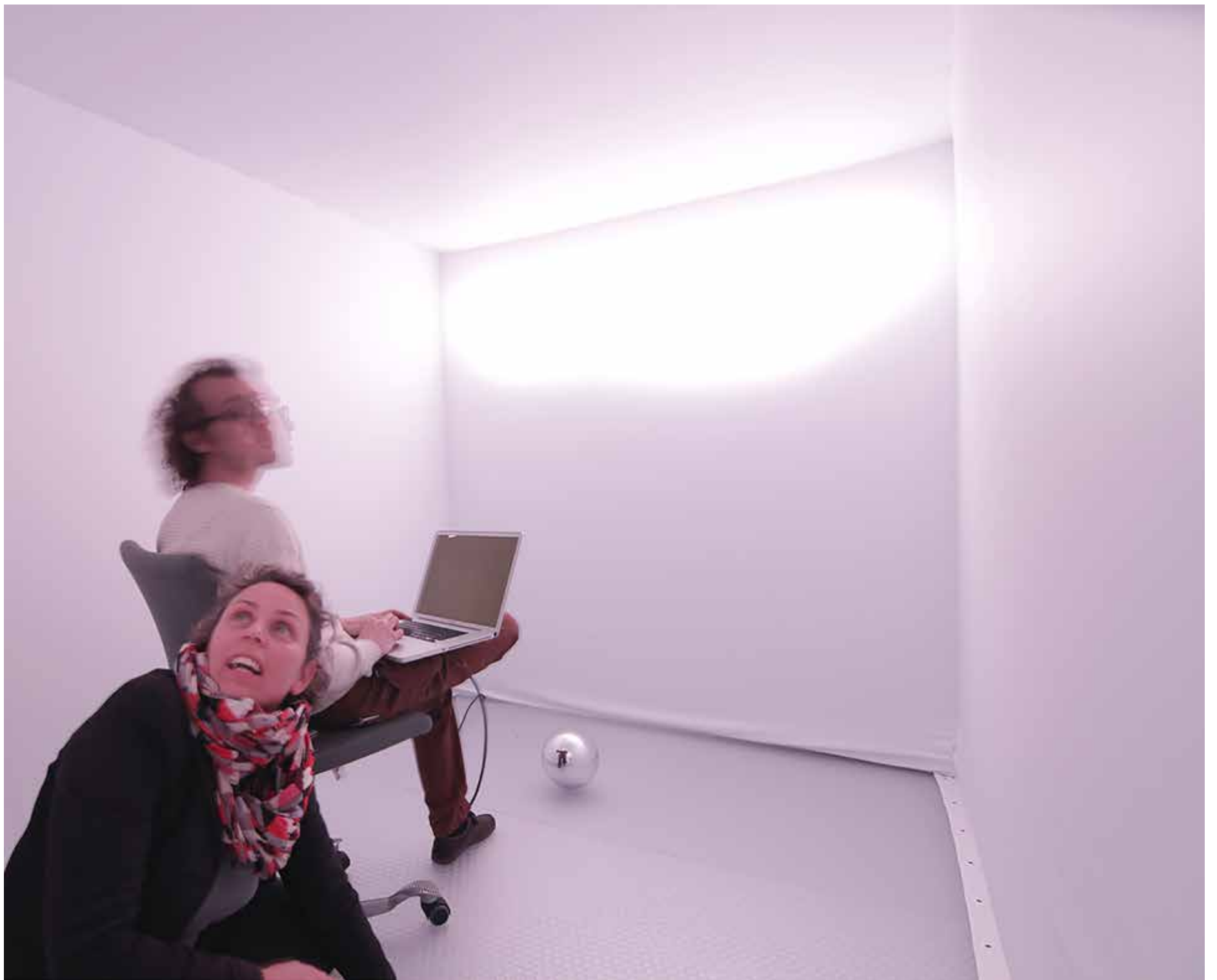
Iscenesatte lysoplevelser

Installationerne iscenesætter et specificeret sted, hvor deltagerne performer deres egen oplevelse. Oplevelserne er guidede af installationens præmis, softwarens programmerede progression, og forskernes instrukser undervejs. I undersøgelserne benyttes oplevelsesbaserede designmetoder, hvor installationerne fungerer som øvelsesrum for netop at kvalificere oplevelsen af, at opholde sig og bevæge sig i dynamisk foranderlige lyssætninger. Heri indgår synsadaptationen som et aktivt aspekt, hvor synsperceptionens kontinuerlige tilpasninger til den til enhver tid givne lyspåvirkning kan medtages i analyserne af de dynamiske designs.

Installationerne iscenesætter undersøgelser med interesse for de dynamiske lysdesigns indflydelse på oplevelsen af rummets form og komposition. Gennem undersøgende handlinger afprøver deltagerne lyskompositionernes indflydelse på evnen til at orientere sig i rummets geografi og hvordan balancer i lysfarver og lysintensiteter påvirker oplevelsen af retninger, afstande og skala. Fokus i undersøgelserne er på selve oplevelsen af at være tilstede i rummet og hvordan oplevelsen af forholdet til andre mennesker i rummet iscenesættes.

Installationerne fungerer som læringsmaskiner, hvor deltagerne gennem sine afprøvninger opnår en kvalificering af sin evne til at analysere lys-situationernes oplevelsesmæssige parametre. Ved gentagne oplevelsesbe-givenheder udvikles en uddybet designforståelse af de afprøvede lyspa-parametre, – en træning af sansning og perception i en stadig kvalificering af analytisk kapacitet, specifikt på aspekter ved oplevet lys i komplekst dynamisk lysdesign.





Staged Experiences of Light

Each installation stages a specified place, where participants perform their own experiences; guided by the premises of the given installation, the programmed progressions, and the instructions given by the researchers during each experience. As is evident, the studies used experience-based design methods, where the installations function as practice spaces for specifically qualifying the experiences of being and moving in dynamically changing lighting settings. This includes visual adaption as an active aspect, where the continual adaptations of visual perception in relation to the given exposure of light can be included in the analyses of the dynamic designs.

The installations stage investigations interested in the influences that dynamic lighting design has upon the experiences of the form and composition of a given space. Through investigative actions participants test the ways that the lighting compositions influence their ability to orient themselves within the geography of the space and how the balances in light colours and luminous intensities affect their experience of directionality, distances, and scales. In short, the experience of being present in the space as well as one's experience of relationships to other people in the space are staged and brought into focus.

These installations function as experiential learning instruments, where participants – through their testing – obtain a qualification of their abilities to analyse the experiential parameters of lighting situations. Via repeated experiential events, a deeper design understanding of the tested lighting parameters develops. Each is an exercise in sensing and perceiving; a constant qualification of analytical capability, specifically regarding aspects of experiencing light in complex dynamic lighting designs.

Adaptivt lysdesign

Det adaptive lys er baseret på en delvis automatisering af mulighederne for at justere i lysets farvetone og lysniveau, så det tilpasses behov og ønsker. IT understøttelse er den afgørende tekniske udvikling, der fører til adaptive styringssystemer. Mulighederne ved adaptiv lysstyring opstår ved at systemdele, netværk og data flow kan kordineres gennem software, således at de dynamiske variationsmuligheder styres på måder, der meningsfuldt tilpasser sig brugersituationer og design intentioner.

De to installationer White Cube og White Box instrumenterer oplevelsesbaserede undersøgelser som perceptuel aktivitet, hvor lysforholdene undersøges i forhandlingen mellem system og menneske. En af intentionerne med adaptivt lysdesign er, at give brugerne højere grad af kontrol med deres lysomgivelser, hvilket kan ske ved at lade et spekter af adaptationer være til rådighed for brugerne som kvalitative valg. I de to installationer er to forskellige aspekter i spil. I White Cube balanceres rummets lysfarver. I White Box følger lyset personers bevægelser i rum. Ved situationer med flere personer i samme rum indgår sociale relationer i forhandlingerne af hvordan lysdesignet udfoldes.

Styringssystemer med adaptive kvaliteter indeholder blandt andet scenarier for fremtidige valg, som for eksempel hvilke dynamiske variationer der ligger indenfor det ønskelige. Styringssystemerne kan også opsamle og validere tidligere forbrugsmønstre, og derved indikere hvilke valg der skal understøttes eller modarbejdes. Yderligere indeholder de adaptive systemer muligheder for tilpasning til brugernes behov, for eksempel gennem udvidet individuel kontrol og adgang til at bruge de dynamiske lysmuligheder på kvalificerede måder.

Design af adaptive styringssystemer er således en balanceakt i at udvikle lysdesignets muligheder i grænseområdet mellem, hvordan programmet iscenesætter rummet og fortolker aktiviteter, og hvordan mennesket indgår i relationer med de adaptive muligheder.

Software befordre en kommunikativ æstetik, hvor interaktionen mellem bruger og lysdesign bliver et væsentligt parameter i forhold til den overordnede koordinering af brugersituationer og design intentioner. Udviklingen af adaptiv lysstyring indebærer at integrere og koordinere mange tilpasninger samtidigt, ofte samlet i brugerscenarier. Disse kan bestå af scenarier for rummets tilstand, scenarier for de individuelle tilstande knyttet til de enkelte personer, og scenarier for den samvirkende forhandling af scenarierne, – en slags adaptiv koordination af mange skalaer af relationer.

Adaptive Lighting Design

Adaptive lighting is based on a partial automation of the possibilities to adjust the colour tone and brightness levels of light in order to adapt to people's needs and desires. IT support is key to the technical developments that afford adaptive control systems. The possibilities offered by adaptive lighting control are created by the ways that the system components, the network and data flow can be coordinated through software so that the dynamic variations are controlled in ways that meaningfully adapt according to people's situations and design intentions.

The two installations, White Cube and White Box, enable experience-based studies as a form of perceptual activity, wherein lighting conditions are examined in a dialectical exchange between the system and the people participating. One of the intentions of adaptive lighting design is to give people greater control over their lighting environments, which can be achieved by making a range of adaptations available to people as qualitative choices. In the two installations, two different aspects are at play. In White Cube, the light colours are balanced. In White Box, the light follows the movements of the people in the space. In situations with several people occupying the same space, social relations become involved in the negotiations of how the lighting design unfolds.

Control systems with adaptive qualities encompass – among other things – scenarios for future choices; for example, defining which dynamic variations are situated within the ranges of what is desirable. Control systems can also collate and value past consumption patterns; indicating the choices that must be supported or discouraged. Moreover, the adaptive systems contain the ability to adapt to people's needs through expanded individual control, including access to employing the dynamic lighting possibilities in qualified ways.

The design of adaptive control systems is therefore a delicate act of negotiating between the ways a software program stages a given space and interprets activities, and the ways that people interact within the field of adaptive possibilities, when enhancing the opportunities of the lighting qualities.

Software thus can be seen to bear a communicative aesthetic, where the interaction between people and the lighting design is an important parameter in relation to the overall coordination of user situations and the design intentions. The development of adaptive lighting control entails the integration and coordination of many adaptations at the same time, often encapsulated in user scenarios. These may consist of scenarios for the conditions of the space, scenarios for the individual modes that are associated with the individual people in the space, and scenarios for cooperative negotiation of scenarios – a kind of adaptive coordination of many scales of relationships.

Perceptiv konstans i adaptivt lysdesign

Perceptuelle konstanser er involveret i vores forståelser af rumgeometri, skalaer og perspektiver, eller objekters former og aflæsning af andre mennesker, som organiserende perceptive filtre, der danner meningsfulde og sammenhængende oplevelser af omgivelserne. Konstanser af farve og intensitet hen over flader etablerer oplevelsen af kontinuitet i farve og lyshed, selvom der ofte er åbenlyst variation i synsoplevelsen, hvis man ser efter. Et eksempel kan være den tydelige forskel på lysforholdene skabt af dagslyset tæt ved vinduet og lysforholdene dybere inde i rummet. Man kan sige at perceptionen konstruerer abstrakte perceptuelle konstanser, der bringer sammenhæng og stabilitet til de ofte meget varierede forekomster i vores daglige omgivelser.

Filosoffen Alva Nöe (2005) argumenterer i sin kognitive forskning for en forståelse af perceptionens processer som aktive handlinger, hvor perceptionen gennemleves ved egentlige sensomotoriske aktiviteter som at bevæge sig og se sig omkring. Vores evne til at opleve verden omkring os udvikles i processer, hvor vi gennem erfaring opbygger forskellige perceptuelle kategorier, blandt andet perceptuelle konstanser.

Man kan sige at perceptuelle konstanser er et resultat af den abstrakte organisering af ellers relativt komplekse indtryk af den verden vores sanseperception handler i. Disse perceptive processer bidrager til, at vi meningsfuldt kan opleve komplekse situationer, justeret for variationer i omgivelserne. I vores udforskning af verden etablerer vi således funktionelle perceptuelle konstanser til at bringe konsistens i oplevelserne.

De adaptive dynamikker i lysdesignets styring og komposition er med til at sætte rammebetingelserne for fremtidige lysdesigns, og ligesom vi som mennesker har udviklet perceptuelle konstanser i forhold til dagslysets lysvariationer og vores bevægelser i rummet, så vil de mere abstrakte variationer i det adaptive lysdesign blive modsvaret af perceptive konstanser, der er tilpasset de særlige adaptive variationer i lysdesignet.

Spørgsmålet er hvordan lysomgivelser, der dynamisk tilpasser sig menneskelige behov, kan indgå i perceptuelle processer i vores livsverden, og findes der en form for perceptuel fasthed af den oplevelsesmæssige situation, – en form for kontinuitet ved det foranderlige.

Perceptual Constancy in Adaptive Lighting Design

Perceptual constancies are involved in our understandings of spatial geometries, scales, perspectives, the shapes of objects and our reading of other people, as organising perceptual filters that form meaningful and consistent experiences of one's surroundings. Constancies of colour and light intensity over surfaces establish a sense of continuity in colour and brightness, although there often are overt variations in the visual experience if one looks closely. An example would be the clear difference in lighting conditions created by the daylight near to a window and the conditions deeper in the given space. One could say that perception constructs abstract perceptual constancies that bring coherence and stability to the often highly varied occurrences in our daily surroundings.

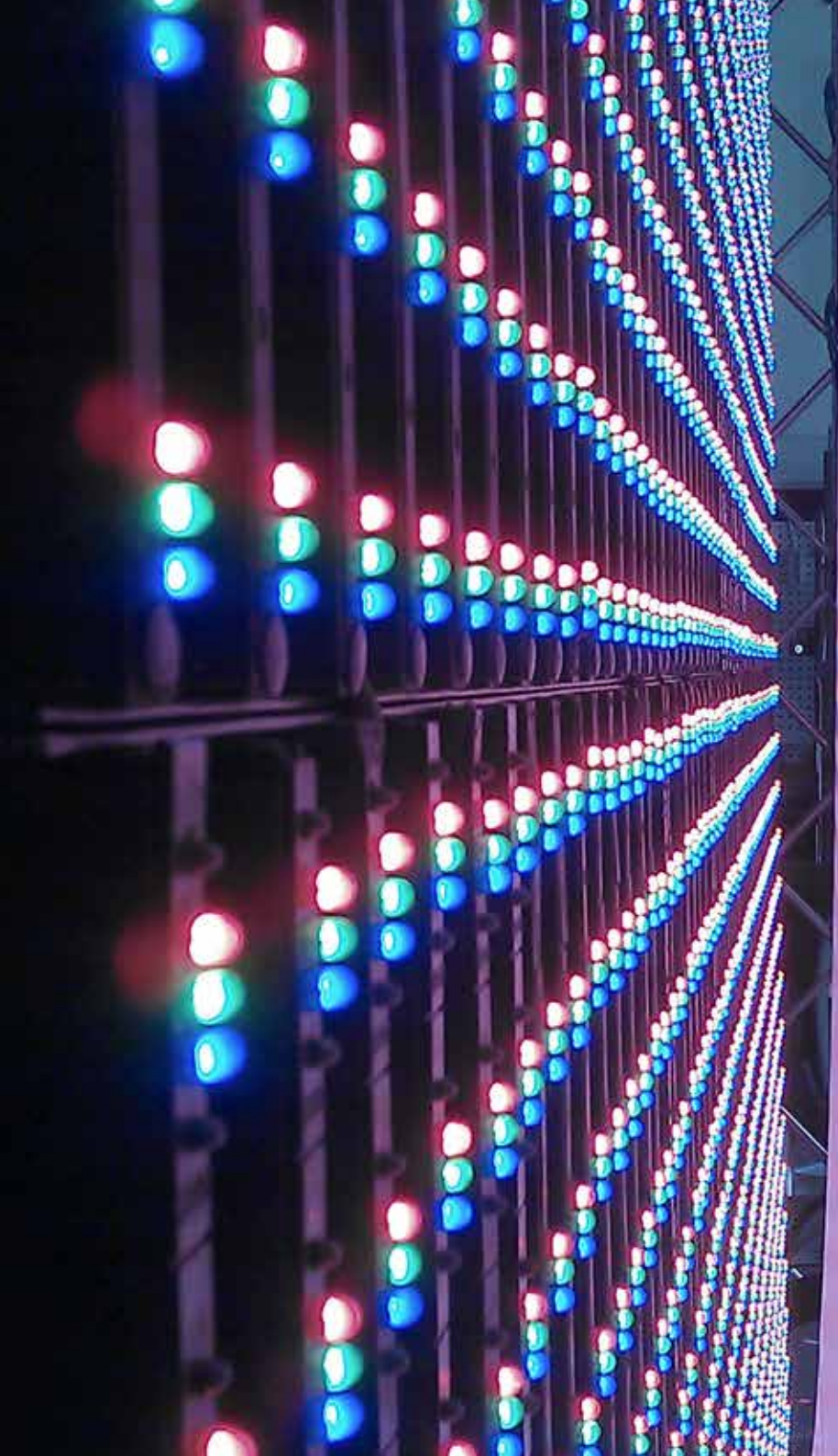
In his cognitive research into understanding the processes of perception as enacted activities, philosopher Alva Noë (2005) argues that actual sensorimotor activities, such as moving and looking about, are essential to perceptual processes. Our abilities to experience the world around us are developed via processes within which we build-up different perceptual categories through experience, including amongst other things perceptual constancies.

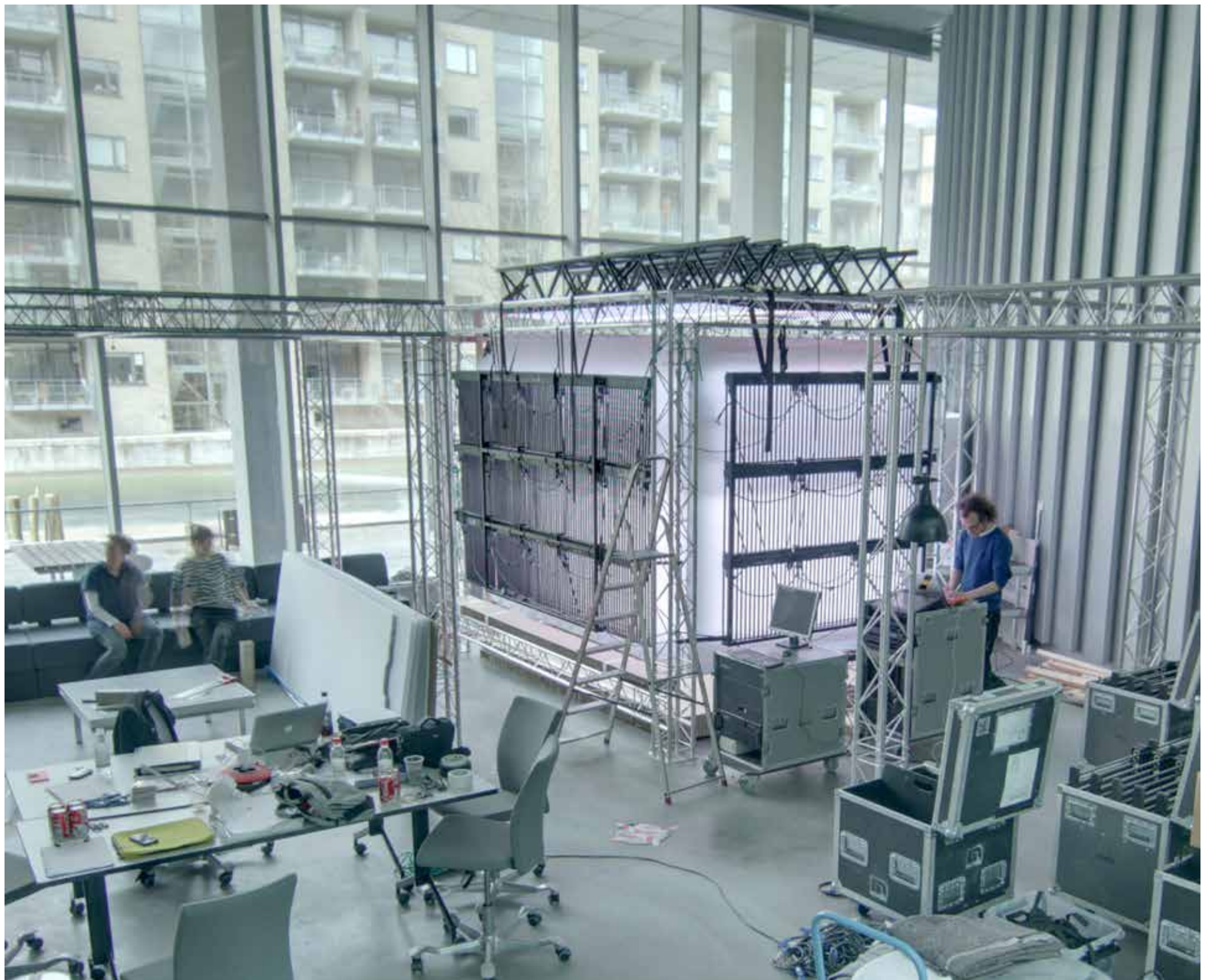
One could say that perceptual constancies are a result of the abstract organisation of otherwise relatively complex impressions of the world within which our sensory perception operates. These perceptive processes contribute to our being able to meaningfully explore complex situations, adjusted for variations in the given environment. Hence, in our exploration of the world we establish functional perceptual constancies in order to bring consistency to our experiences.

The adaptive dynamics in the control and composition of lighting set the scope for future lighting designs. And just as we as humans develop perceptual constancies in relation to daylight's variations and our movements in space, then the more abstract variations in an adaptive lighting design will be counteracted with perceptual constancies that are adjusted to the particular adaptive variations in the lighting design.

The question is then how can lighting environments that dynamically adapts to people's needs be part of perceptual processes in the lifeworld. And does a kind of perceptual fixity of an experiential situation exist – a form of continuity within the changeable?

White cube





White Cube

White Cube er en kube konstrueret med målene 2,4 x 2,4 x 3,6 meter og således i en skala så personer kan opholde sig i den. Kuben er bygget i et mat hvidt transluscent materiale, og når den belyses udefra af de helt omsluttende LED paneler, kan lyset opleves indefra, uden at man ser selve lyskilden. Fladerne kan oplyses separat og i mindre områder. Kuben er ophængt og hævet fra underlaget, således gulvet kan oplyses ligesom væggene. White Cube er på denne måde et instrument til iagttagelse af belysning, hvor selve rummets flader er lyskilderne.

Installationen undersøger de nye belysningsmæssige vilkår, der opstår, når LED teknologien gør det muligt at ophæve den punktformede lyskilde, som vi kender den i dag, og erstatte denne med lysgivere i mere ubegrænset form og indbygget i de arkitektoniske materialer. Lyskilderne flytter fra loftet til alle rumflader, og kan placeres tættere på brugssituationen og formes mere præcist til lyssituationens behov. I installationen kan man undersøge de lysmæssige og optiske forhold der opstår, når et rum ikke oplyses af lyskilder, der lyser på vægge, gulv og loft, men hvor lyset er integreret i arkitekturen i en sådan grad, at selve rummet lyser.

Lyssituationen i White Cube skaber et diffust lys med uniforme lysende flader og et rum næsten uden skygge eller konturtegninger. Det let diffuse lys fra en stor flade har, på samme måde som refleksionslys, en større jævn udbredelse gennem rummet. Her er tilsyneladende ingen primære lyskilder eller direkte lys, men man kan sige at alle flader fremstår som simuleret reflekslys med diffuse flow af lys fra alle retninger. Man kan således gå eller ligge på lyset, uden derved at spærre for lyset.

Det stærkt diffuserende lys i kuben forstærker en sansning af processen i synsperceptionens adaption af farver og intensiteter, ligesom det opleves, når man befinder sig omsluttet af tåge. Situationen tydeliggør vores afhængighed af forskelle og rumlige variationer i dannelsen af rumlige synsindtryk. Variationer i lysets fordeling af lysfarver og lysintensiteter er afgørende for en rumlig forståelse. Undersøgelserne viser, at en balancering af lysfarver med for eksempel en varm og tre kolde lysende vægge etablerer en form for stabilisering af rummets orientering, og at man derfor relativt ubesværet kan navigere i rum med store lysende flader, hvis der etableres forskel og dynamik i lysets farver. Variation i lysfarver tydeliggør desuden formtegningen af materialer, objekter og personer, og beforder tydeligere aflæsninger af ansigtstegninger og relationer.

Lysets rumlige komposition bestemmer, hvordan vi og andre mennesker oplyses, og således hvordan vi fungerer sammen, aflæser hinanden og interagerer. Undersøgelserne viser at når alle vægge i rummet er oplyst ensartet, er det sværere at se folk foran sig og aflæse udtrykket i deres ansigter. Andre mennesker fremstår som silhuet mod den lysende baggrund, og optræder mere som skygger end som form i rummet. Hvis der derimod er intensitetsforskelle eller farvetoneforskelle imellem væggene, opstår en tydeligere formdannelse, og andre mennesker og deres ansigtsudtryk fremstår tydeligere.

White Cube installationen oplyses af styrbare LED paneler, hvor man kan skabe lysflader, der flytter sig dynamisk hen over væggene. Lyskildernes form og placering kan bringes til at flytte sig efter behov og opstå alt efter designet i den adaptive lysstyring. Ved at udnytte de billeddannende muligheder i distributionen af lys i rumfladerne, kan man reproducere genkendelige dagslysfænomener og således forstærke oplevelsen af en lysfrembringelse, som er forbundet med vejr og lysforhold udenfor, selvom man opholder sig indenfor.

White Cube

White Cube is a cube designed with the dimension of 2.4 x 2.4 x 3.6 meters, and thus exists in a scale that people can enter into. The cube is constructed of a matte white translucent material, and when it is illuminated from the outside by the completely encasing LED panels, the light is experienced on the inside without one ever noticing the light sources. The cube can be illuminated on all its surfaces, as well as being partly illuminated on smaller areas of the various surfaces. The cube is suspended and raised from the floor so that the floor surface, like the walls, can also be illuminated. In this way, White Cube can be understood as an instrument for observing the lighting, where the surfaces of the space itself are the light sources.

This installation examines the new lighting conditions that occur when LED technology makes it possible to repeal the single-point light source that we have grown accustomed to today, and replace them with *light giving bodies* that are available in limitless forms and which can be embedded into architectural materials. The single-point light sources of the past now move from the ceiling to exist in all surfaces. Light sources can now be placed closer to user situations and can be shaped more precisely according to the specific needs of the lighting situation at-hand. In the White Cube installation, one can examine the consequences of illumination and optical conditions that occur when a space is not illuminated by light sources that project onto the walls, floor and ceiling, but where the light is integrated into the architecture to such an extent that the space itself is illuminating as a luminous luminaire.

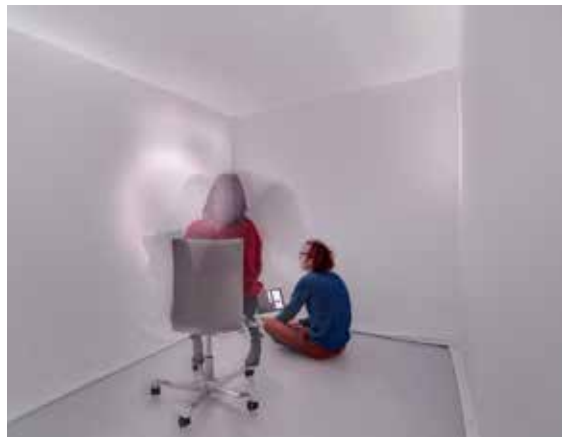
The lighting situation inside White Cube creates diffuse light with uniform light-emitting surfaces, and a space that exists almost completely without any shadows or contour forms. Much akin to the qualities of reflected light, the soft diffuse light from any one of White Cube's major surfaces creates a large and even propagation of light throughout the space. Here, there are no apparent primary light sources or direct illumination. Yet at the same time, one can say that all the surfaces appear as simulated reflected light with a diffuse flow of illumination coming from all directions. Consequently, one can walk in or recline on the light without obstructing the light.

The highly diffusing light inside White Cube augments a sensing of the adaptation process of visual perception in terms of light colours and luminous intensities; much akin to the experience of being enveloped in fog. And this clarifies our dependence on differences and spatial variations in the formation of our spatial visual impressions. Variations in the distribution of light colours and luminous intensities are essential to our spatial understandings. These investigations illustrate that a balancing of the colours of light (for example, using one warm and three coolly illuminating walls) establishes a form of stabilisation in terms of spatial orientation. Therefore, one can navigate around in the space relatively effortlessly in relation to the large luminous surfaces, when differences and dynamics in light colours are created. Variations in light colours also clarify the formal definition of materials, objects and people, and moreover promote more lucid readings of facial characteristics and spatial relations.

Light's spatial compositions determine how we and other people are illuminated, and thus how we work together, read one another, and interact together. Our studies show that when all the walls in the space are uniformly illuminated, it is harder to see people right in front of oneself and to read others' facial expressions. Other people appear silhouetted against the illuminating backgrounds; existing more as shadows than as concrete bodily forms in the space. In contrast, differences in intensities or colour tones between the walls create a clearer pattern formation, and other people and their facial expressions appear more well-defined.

The White Cube installation is illuminated by controllable LED panels that enable one to create illuminating surfaces that move dynamically across the walls. The form and location of the illuminating bodies can be moved as required and occur depending upon the design that is programmed into the adaptive control system. The dynamic distribution of the lighting on the surfaces enables an option of image formations, and allows for reproductions of recognisable daylighting phenomena. And this thus enhances the experiences of a behaviour of light connected to the weather and luminance conditions outdoors even though one is indoors.

















White Box

White Box

White Box er opstillet som en scenografisk iscenesættelse, med tre sider dækket af hvidt stof, et mellemgråt filtet gulvtæppe, en rig med lys for oven, og en åben side hvorfra rummet kan betragtes udefra. Rummet er en kube med sidelængder og højde på 3,4 meter. Rummet er lige præcist stort nok til at opleves som et sted, hvor man kan bevæge sig og have afstand til væggene, og hvor to personer kan undersøge deres relative iscenesættelse i et forhold til hinanden.

Installationen er indrettet med 16 downlights i en grid i loftet, som muliggør at indstille lyset i zoner af lysfarver og lysintensiteter. Lyssætningen fra oven kan derved geografisk følge personen i rummet med sin rettede lodrette belysning. Styringssoftwaren kan indstilles til en serie af iscenesættelser, hvor lyset følger personen i rummet, – med varm eller koldt lys, eller med en zone af mørke. Væggene er af hvidt mat stof, som er delvis lystransparent, således scenografien kan opnå en lysende kvalitet ved hjælp af bagbelysning. Med variation i henholdsvis lysfarve og lysintensitet i de lysende vægge skabes et ensartet vandret diffust lys i rummet. Rummet kan således balanceres med lys fra væggene, som blander sig med eller overdøver refleksionslysets lyshed og farve. Der kan således frit kombineres mellem det rettede lys fra oven og det diffuse sidelys.

White Box er et oplevelsesinstrument, som iscenesætter en træning af synsperceptionen, der udvikler og understøtter analyse af de oplevelsesmæssige aspekter ved adaptivt lysdesign. Der skiftes frem og tilbage mellem indstillingerne for at konfrontere og sammenligne forskellige typer lysoplevelser. For eksempel veksles mellem at bevæge sig i lys og mørke, eller i varme og kolde indstillinger. Hver kombination tydeliggør oplevelsen af de relative forhold i lyssætningerne, og bringer samtidig synsadaptationens dynamikker frem, hvor synets tilpasninger til lysintensiteter og lysfarver bliver tydelige at opleve. Ved gentagne forandringer, hvor den dynamiske skiften mellem forskellige indstillinger opleves over længere forløb, tydeliggøres samspillet mellem dynamikken i lyset og dynamikken i lysperceptionen.

White Box

White Box is setup as a scenographic staging comprised of three sides covered in white cloth, a medium grey coloured felt carpet, an overhead gridded rig with downlights mounted on to it, and an open side from which the box's interior can be observed from outside. As its name implies, the space is a cube and in this case it has a length and height of 3.4 meters. The space is exactly large enough to be experienced as a place, where one can move about and still have a bit of distance to the walls, and where two people can explore their relative staging in a relationship to one another.

Because the installation is equipped with 16 downlights positioned on a grid attached to the structural frame of the ceiling, it is possible to configure the lighting into zones of light colours and luminous intensities. The lighting arrangement overhead is able to geographically follow a person in the space via directed vertical lighting. The control software can be configured into a series of stagings in which the light follows a person in the space using warm or cool light, or using a zone of darkness. The white matte fabric walls are partially transparent to light, thereby allowing the scenography to achieve a luminous quality using backlighting. A variation in the respective light colour and luminous intensity in the illuminating walls creates a uniform, horizontal diffuse light in the space. As a result, the space can be balanced using illumination from the walls, which can interfere with or drown out the brightness and colour of the reflected light. Likewise, one can freely combine the directed illumination from above with diffuse illumination from the sides.

White Box is an experiential instrument that stages an exercise in visual perception, which enhance the capacity to analyse and argue for the experiential aspects of adaptive lighting design. One switches back and forth between settings in order to confront and compare different types of lighting experiences: for example, the alternating movement between light and darkness, or between warm and cool settings. Each combination clarifies the experience of the lighting arrangements' relative conditions, and simultaneously brings the dynamics of visual adaption to the fore, where vision's adaptations to luminous intensities and light colours become more apparent to experience. With repeated changes – where the dynamic shifts between the different configurations are experienced over a longer duration –, the interactions between the dynamics of the light and the dynamics of lighting perception are brought into enhanced experiences.

White Box test serie

Ovenlyset følger personen i rummet – ingen sidelys

- (1) *Lysset følger - kold ovenlys følgespot i kontekst af mørke – ingen sidelys*
- (2) *Lysset følger - varm ovenlys følgespot i kontekst af mørke – ingen sidelys*
- (3) *Mørket følger – mørk ovenlys følgespot i kold lysbeds kontekst – ingen sidelys*
- (4) *Mørket følger – mørk ovenlys følgespot i varm lysbeds kontekst – ingen sidelys*
- (5) *Lysset følger – kold ovenlys følgespot i varm lysbeds kontekst – ingen sidelys*
- (6) *Lysset følger – varm ovenlys følgespot i kold lysbeds kontekst – ingen sidelys*

Jævnt fordelt ovenlys – med jævnt fordelt sidelys

- (7) *Koldt jævnt fordelt ovenlys i kraftigt varmt jævnt fordelt sidelys*
- (8) *Varmt jævnt fordelt ovenlys i kraftigt koldt jævnt fordelt sidelys*
- (9) *Koldt jævnt fordelt ovenlys i svagt varmt jævnt fordelt sidelys*
- (10) *Varmt jævnt fordelt ovenlys i svagt koldt jævnt fordelt sidelys*

Ovenlyset følger personen i rummet – med jævnt fordelt sidelys

- (11) *Lysset følger – kold ovenlys følgespot i jævnt fordelt varmt sidelys*
- (12) *Lysset følger – varm ovenlys følgespot i jævnt fordelt koldt sidelys*

Ovenlyset og sidelysset følger personen i rummet

- (13) *Mørket følger – mørk ovenlys følgespot i kold lysbeds kontekst – medfølgende mørke i koldt sidelys*
- (14) *Mørket følger – mørk ovenlys følgespot i varm lysbeds kontekst – medfølgende mørke i varmt sidelys*
- (15) *Lysset følger – kold ovenlys følgespot i varm lysbeds kontekst – medfølgende koldt lys i varmt sidelys*
- (16) *Lysset følger – varm ovenlys følgespot i kold lysbeds kontekst – medfølgende varmt lys i koldt sidelys*

White Box Test Series

Light from above follows people in the space - no side illumination

- (1) *Light follows – cool followspot overhead in a context of darkness – no side illumination*
- (2) *Light follows – warm followspot overhead in a context of the dark – no side illumination*
- (3) *Darkness follows – dark followspot overhead in a coolly lit context – no side illumination*
- (4) *Darkness follows – dark followspot overhead in a warmly lit context – no side illumination*
- (5) *Light follows – cool followspot overhead in a warmly lit context – no side illumination*
- (6) *Light follows – warm followspot overhead in a coolly lit context – no side illumination*

Evenly distributed light from above – with evenly distributed side illumination

- (7) *Cool, evenly distributed light from above in bright, warm, evenly distributed side illumination*
- (8) *Warm, evenly distributed light from above in bright, cool, evenly distributed side illumination*
- (9) *Cool, evenly distributed light from above in faded, warm, evenly distributed side illumination*
- (10) *Warm, evenly distributed light from above in faded, cool, evenly distributed side illumination*

Light from above follows people in the space – with evenly distributed side illumination

- (11) *Light follows – cool followspot overhead in warm, evenly distributed side illumination*
- (12) *Light follows – warm followspot overhead in cool, evenly distributed side illumination*

Light from above and the sides follows people in the space

- (13) *Darkness follows – dark followspot overhead in a coolly lit context – accompanying darkness in cool side illumination*
- (14) *Darkness follows – dark followspot overhead in a warmly lit context – accompanying darkness in warm side illumination*
- (15) *Light follows – cool followspot overhead in a warmly lit context – accompanying cool light in warm side illumination*
- (16) *Light follows – warm followspot overhead in a coolly lit context – accompanying warm light in cool side illumination*



(1) Lyset følger - kold ovenlys følgespot i kontekst af mørke – ingen sidelys / Light follows – cool followspot overhead in a context of darkness – no side illumination





(2) *Lysset følger - varm ovenlys følgespot i kontekst af mørke – ingen sidelys / Light follows – warm followspot overhead in a context of the dark – no side illumination*





(3) *Mørket følger – mørk ovenlys følgespot i kold lysbeds kontekst – ingen sidelys / Darkness follows – dark follows:spot overhead in a coolly lit context – no side illumination*





(4) Mørket følger – mørk ovenlys følgespot i varm lysbeds kontekst – ingen sidelys / Darkness follows – dark followspot overhead in a warmly lit context – no side illumination





(5) Lyset følger – kold ovenlys følgespot i varm lysbeds kontekst – ingen sidelys / Light follows – cool followspot overhead in a warmly lit context – no side illumination





(6) Lyset følger – varm ovenlys følgespot i kold lysbeds kontekst – ingen sidelys / Light follows – warm followspot overhead in a coolly lit context – no side illumination





(7) Koldt jævnt fordelt ovenlys i kraftigt varmt jævnt fordelt sidehlys / Cool, evenly distributed light from above in bright, warm, evenly distributed side illumination





(8) *Varmt jævnt fordelt ovenlys i kraftigt koldt jævnt fordelt sidelys / Warm, evenly distributed light from above in bright, cool, evenly distributed side illumination*





(9) Koldt jævnt fordelt ovenlys i svagt varmt jævnt fordelt sidelys / Cool, evenly distributed light from above in faded, warm, evenly distributed side illumination





(10) Varmt jævnt fordelt ovenlys i svagt koldt jævnt fordelt sidelys / Warm, evenly distributed light from above in faded, cool, evenly distributed side illumination





(11) Lyset følger – kald ovenhys følgespot i jævnt fordelt varmt sidehys / Light follows – cool followspot overhead in warm, evenly distributed side illumination





(12) Lyset følger – varm ovenhys følgespot i jævnt fordelt koldt sidehys / Light follows – warm followspot overhead in cool, evenly distributed side illumination





(13) Mørket følger – mørk ovenlys følgespot i kold lysbeds kontekst – medfølgende mørke i koldt sidelys / Darkness follows – dark followspot overhead in a coolly lit context – accompanying darkness in cool side illumination





(14) Mørket følger – mørk ovenlys følgespot i varm lysbeds kontekst – medfølgende mørke i varmt sidelys / Darkness follows – dark followspot overhead in a warmly lit context – accompanying darkness in warm side illumination





(15) Lyset følger – kold ovenhys følgespot i varm lysbeds kontekst – medfølgende koldt lys i varmt sidelys / Light follows – cool followspot overhead in a warmly lit context – accompanying cool light in warm side illumination





(16) Lyset følger – varm ovenlys følgespot i kald lysbeds kontekst – medfølgende varmt lys i koldt sidelys / Light follows – warm followspot overhead in a coolly lit context – accompanying warm light in cool side illumination



Menneskets oplevelse af adaptivt lys
Human Experience of Adaptive Lighting

Menneskets oplevelse af adaptivt lys

De virkelig interessante kvaliteter ved et adaptivt lysdesign ligger i rytmer og skalaer af de adaptive variationer, snarere end i de konkrete tilpasninger af form og funktion, – i relationens æstetik og interaktionens kvalitet, snarere end i adaptionens konkrete funktion. Samtidig er adaptionens største problem netop den dynamiske kvalitet af tilpasningen. Virker forandringerne forstyrrende? Passer dynamikkerne ind i en oplevelse af det arkitektoniske design, indretningen af rummet og menneskers handlinger? Eller griber dynamikken forstyrrende ind og fjerner fokus i menneskers gøremål? De dynamiske kvaliteter i lystilpasningen åbner for yderligere spørgsmål til hvordan interaktionen designes, således at adaptionen i lyset opleves som væsentligt for individets gøremål, og at styringens logik er befordrende at orientere sig igennem.

Oplevelsesinstrumenterne er eksplorative installationer, hvor man kan foretage bevægelsesbaseret udforskning af adaptivt lysdesign som konkret situation med konkret oplevet effekt i fuldskala iscenesættelser. Her etableres situationer for analytisk fordybelse i aspekter af adaptivt lysdesign, som kræver erfaring og udvikling af analytiske sanse- og perceptionskvaliteter. Dette forskningsdesign muliggør at udvikle og justere på det adaptive lysdesign og styringssystemerne, samtidig med at effekterne af designforsøgene opleves og udfordres af handlinger i rummet.

Interaktionen mellem personer og lysdesignet

Den konkrete adaptive funktion i White Box er at lyset følger personen i rummet. Men straks det adaptive følgelys går i gang opstår opmærksomhed på de dynamiske variationer i følgelyset. Man kan spørge om lyset tilhører rummet eller personen, – går personen med lyset eller tilpasser lyset til personen? Det ligger bl.a. i dynamikkens animation af forholdet, – om lyset går foran eller følger efter, eller, – er der en opmærksomhed i lyset på den ønskede retning af bevægelse i det næste øjeblik? Er man trængt inde i lysrummet eller åbner lysrummet udefter og skaber rum for handlinger? Leder følgelyset, følger det bagefter, eller følges personen og lyset ad?

Human Experience of Adaptive Lighting

The really interesting qualities of adaptive lighting design can be seen to exist in the rhythms and scales of the adaptive variations, rather than in the specific adaptations of form and function – i.e. in the aesthetics of the relations and the quality of the interactions, rather than in the specific functional adaption. At the same time, the adaption's greatest problem is precisely the dynamic quality of the adaptation. Do the variations seem disturbing? Do the dynamics fit into an experience of the architectural design, the interior design, and people's actions? Or do the dynamics interfere and remove the focus on people's activities? This raises further questions regarding how the interaction should be designed so that the lighting adaption is experienced as being essential to an individual's activities. And likewise so that the logic of the control system is conducive to helping people orient themselves spatially.

The experiential instruments are explorative installations, within which one can undertake movement-based explorations of adaptive lighting designs as concrete situations with concrete experiential effects in full-scale stagings. Here, situations affording analytical immersions into aspects of adaptive lighting design are established. These situations require the attainment of experience and the development of analytical senso-motoric intelligence and perceptual capacities. The design of this research makes it possible to develop and adjust adaptive lighting designs and control systems, whilst at the same time the effects of the design experiments are experienced and challenged by the actions in the given space.

Interaction Between People and Lighting Design

The specific adaptive function of White Box is for light to follow a person in the space. As soon as the adaptive tracking light is initiated, one's attention is tuned into the dynamic variations of the followspot. One may then ask whether the light belongs to the space or to the person in the space: Does the person move according to the light or does the light adapt to the person moving? It is, amongst other things, the dynamics' animation of the relationship that determines if the light of the followspot moves in front of one or follows one. Is there attention to the light in one's desired direction of motion in the next moment? Does one enter into the light-zone, or does the light-zone open outwards and create space for further actions? Does the followspot lead, trail behind, or do the person and the light move in accord?



Varmt eller koldt lys følger personer

Det varmere og køligere lys etablerer en tydelig relationel kontrast, oprettet af farvebalancen i den rumlige prioritering. Hvordan de forskellige kombinationer af varmt og koldt lys situerer personen og relationen, har ganske givet store individuelle variationer. Testpersonerne pointerer en vis udsathed eller udstilling ved at være i et kolde følgelys, men også en oplevelse af tydeligere tilstedeværelse og klarere positionering i rummet. Tilsvarende oplevedes en større nærhed og tryghed ved varmt følgespot, men også en mere utydelig fremtoning.

Warm and Cool Light Follows People

The warmer and cooler light establishes a clear relational contrast, established by the colour balance in the priorities of the space. How the various combinations of warm and cool light situate the person(s) and the relationship(s) certainly offers large individualised variations. Test-participants noted a certain degree of vulnerability or exhibitionism by being in the zone of a coolly lit followspot; yet also a feeling of greater presence and clearer positioning in the space. Similarly, they noted experiencing heightened senses of closeness and security when in the zone of a warmly lit followspot; yet, also with a more indistinct appearance.







Lyset og mørket følger personer

Udover de mere kendte oplevelser med følgelys, så undersøges her den interessante konsekvens af det omvendte forhold: at lade mørket følge personen i rummet. Det er et skifte fra at benytte følgelyset som følgespot, som i teatret, hvor man skal se personen, – personen skal fremføres og tydeliggøres. Det resulterer i blanding, at omgivelserne synes mørke og utydelige, og at andre mennesker er henlagt i skygge. Oplevelserne fremstår modsatte, når mørket følger. Her er der ingen blanding, for der er ingen lys rettet mod stedet hvor personen opholder sig. Omgivelserne er tydelige og veloplyste, og andre mennesker fremstår tydelige og nærværende.

Light and Darkness Follows People

In addition to the aforementioned more well-known experiences with followspots, the investigations staged the interesting consequences of the inverse relationship: namely, also letting the darkness follow a person in the space. This is a shift from using the followspot as a spotlight, as is the case traditionally in theatre, when the audience needs to see someone performing on stage – i.e. when a person acting needs to be highlighted and seen clearly. This kind of lighting results in glare and in the surroundings seeming dark and indistinct, as well as resulting in the others on stage being rendered in shadow. The experiences are the opposite of this when darkness follows people. When darkness follows there is no glare, because there is no light directed towards the place where the person being followed is located. Also the surroundings are clear and well-lit, and the other people appear visually clear and present.







Relationer mellem mennesker

Når der er to personer, én i følgelyset og én udenfor, iscenesættes et relationelt forhold, og der startes overvejelser om, hvordan man fremstår for hinanden. Der opstår en social orientering i den rumlige organisering, som en direkte konsekvens af prioriteringer i lyset, og hvem der bliver fulgt af lyset (eller mørke). Testbrugere formulerer deres oplevelser af situationer i følgelyset som grader af hvordan den anden person virkede mere fjern eller nærværende, - eller fremstod mere tydeligt eller tilbagetrukket.

Relations Between People

When there are two people inside the White Box installation – one in the zone of the followspot and one in the surrounding space –, they are staged into an interactive relationship with one another. In this, begins considerations of how each one appears to the other. There is thus a social orientation in the spatial organisation that is a direct consequence of the lighting priorities, as well as of who the light (or darkness) follows. Test-participants have formulated their experiences of the situations of being in the followspot as degrees of the other person seeming to be more remote or more present. They also noted how the other person appeared to be more pronounced or more withdrawn.





Det adaptive lys som flydende konstanser
Adaptive Lighting as Fluid Constancies

Det adaptive lys som flydende konstanser

Både de dynamiske muligheder introduceret med adaptive softwarestyringer, og de mere åbne designmuligheder med LED lyskilder, udfordrer grundlæggende strategier i lysdesign. Variation og dynamisk tilpasning bliver iboende kvaliteter i lysdesignet, og kunstlysets fremtræden påvirkes af individuelle intentioner og interaktion mellem personer og deres omgivelser. LED teknologien muliggør nye design af lyskilder og lysende materialer, som indgår mere komplekst distribueret og indbygget i bygningskroppen.

Den største forandring er måske, at lyskilderne ikke længere er bundet til faste funktionsmåder. Fremtidigt lysdesign vil udfolde sig i interaktion med mennesker og vil således i sin virkning fremtræde som beslutninger tilrettelagt i software. Vi kan allerede inddrage i designet at vi kan flytte vores lamper, og bestemme hvilke der er tændt, og hvornår de er tændt. Vi kan designe lyskildernes form og placering. Med et adaptivt lysdesign og LED lyskilder opstår yderligere muligheder, hvor særligt lysdesignets potentielle variationer i det overordnede design, samt de dynamiske muligheder med lysets farve og intensitet, kommer i fokus. Hvilke kvaliteter kan udvikles i dynamikken af adaptionen og forandringerne? Til hvilken grad følger adaptionen designvalg, personlige præferencer eller brugsscenarier? Hvordan kombineres disse muligheder med dagliglivets konkrete krav og øjeblikkets æstetiske ønsker?

Den danske forsker Ulrik Schmidt udvikler på den æstetiske problematik med de mere flydende tilstande i lysets og rummets form, som også det adaptive lys introducerer. I sit essay: *Om det ambiente rum mellem forskelsløshed og figurativitet* (Schmidt 2010 s. 8-10) diskuterer han de særlige kvaliteter ved det ambiente rum. Her uddyber han, at det ambiente rum fremstår som intensiteter snarere end som konturer og former, skalaer og perspektiver.

Man kan sige, at med den formopløsende varians i adaptiv dynamik „indsættes intensiteten således som rumdefinerende parameter“ (s. 8) og de „gradvise og graduerede modulationer i rummet udfolder på forskellige vis en i konkret forstand fortættet passage [...] som subjektet kan følge intentionelt eller fysisk indtræde i uden på noget tidspunkt at forlade omgivelserne. Formationerne og modulationerne tager som kontinuerte, intensive variationer konkret del i omgivelsen.“ (s. 9-10)

Der opstår en ny fasthed i oplevelsen af rummets form gennem sammenhænge opstået ved intensiteter i en ellers dynamisk foranderlig kontekst, – en sammenhæng i oplevelsen befordret af de perceptive konstanser, hvor „omgivelsernes forskellige elementer væver sig [...], i al deres forskellighed, sammen i et *konsistent* plan“ (s. 7).

De adaptive dynamikker genererer således en kontinuerlig variation i rumdefinitionerne, som ophæver det relationelle rums fasthed i kategorier af skala, form og perspektiv, for i stedet at introducere ambiens, defineret ved flydende konstanser af intensiteter i forandringerne.

Adaptive Lighting as Fluid Constancies

Both the dynamic possibilities introduced via adaptive software control and the more open-ended design potentials of LED light sources challenge the foundational strategies of lighting design. Variation and dynamic adaptation become intrinsic qualities of lighting design, and the appearance of artificial lighting is influenced by individual intentions and interaction amongst people and their surroundings. LED technology enables the design of new light sources and light-emitting materials, which are more complexly distributed and embedded into the body of a building.

The biggest change at present is perhaps the fact that light sources are no longer tied to fixed functional designs and purposes. Future lighting designs will appear and exist more as decisions designed into software, unfolded as interactions with people. In a design we can already include the ability to fluidly move the location of our lamps, as well as to determine which ones will be turned on/off, when and where. We can similarly design the light source's forms and locations. With adaptive lighting design and LED light sources additional opportunities arise, wherein the overall potential variations in the lighting design and the dynamics of light colour and luminous intensity come particularly into focus. What qualities can be developed in the dynamics of the adaptations and variations? To what extent does the adaption follow design decisions, people's personal preferences, and/or usage scenarios? How do we combine these possibilities with the concrete requirements of everyday life and the aesthetic desires of the moment?

The Danish researcher Ulrik Schmidt builds upon the aesthetic problem related to the more fluid states of the forms of light and space; which are also introduced in adaptive lighting. In his essay entitled '*Of Ambient Space between Indifference and Figurativity*' (Schmidt 2010, pp. 8-10, authors translation), he discusses the special qualities of ambient space. Here he suggests that ambient space appears as intensities rather than as contours, shapes, scales, and perspectives.

One can say that with the dematerialising variance of adaptive dynamics "intensity is added as the spatially defining parameter" (p. 8), and the "gradual and graduated modulations in space unfold in different ways in a condensed passage in a concrete sense [...] which the subject can follow intentionally, or physically enter into, without ever leaving the environment at any time. Formations and modulations concretely take part in the environment as continuous, intensive variations" (pp. 9-10).

There arises a new firmness in the experience of a space's shape through relationships arising in intensities in an otherwise dynamically changing context – a relationship in the experience facilitated by the perceptive constancies, where "the surrounding's different elements weave [...], in all their diversity, together into a consistent plan" (p. 7).

Adaptive dynamics thus generate a continual variation in spatial definitions, retracting the firmness of relational space in terms of the categories of scale, form, and perspective – in order to instead introduce ambience, defined by fluid constancies of intensities occurring within changes.

Referencer / References:

Böhme, Germot (2013) The art of the stage set as a paradigm for an aesthetics of atmosphere. In *Ambiances* <http://ambiances.revues.org/315> (visited December 18, 2014)

Cuttle, Christoffer (2008) (second edition) *Lighting by Design*. Amsterdam: Architectural Press Elsevier, Butterworth-Heinemann.

Frandsen, Sophus (1984) *Lysset i rummet og lyset på tingen*. Lampetten, særtryk, nr. 2, København: Lysteknisk Laboratorium og Lysteknisk Selskab.

Madsen, Merete (2002). *Lysrum – som begreb og redskab*. Ph.D. afhandling. København: Kunstakademiets Arkitektskole.

Mathiasen, Nanette & Voltlen, Nina (2008). Light and Shadow. In Torben Dahl (ed.) *Climate and Architecture*, London: Routledge.

Michel, Lou (1996) *Light: The Shape of Space*. New York: Van Nostrand Reinhold.

Noe, Alva (2006) *Action in Perception*. Cambridge Massachusetts: MIT Press.

Petersen, Kjell Yngve & Søndergaard, Karin (2013) Light as Experiential Material, in Matusiak, Barbara Szybinska & Anter, Karin Fridell (eds.) *Nordic Light and Colour 2012*. Trondheim: NTNU, the faculty of Architecture and Fine art,

Petersen, Kjell Yngve & Søndergaard, Karin (2011) Material evidence as staged experientiality in Beim, Ann & Thomsen, Mette Ramsgaard (eds.) *The Role of Material Evidence in Architectural Research*. Copenhagen: The Royal Danish Academy of Fine Arts, School of Architecture, Design and Conservation.

Schmidt, Ulrik (2010) Om det ambiente rum mellem forskelsløshed og figurativitet. In Henrik B. Andersen (ed) *Sliding Zones*. (pp 6-11). København: Kunsthal Charlottenborg.

Søndergaard, Karin (2010) *Participation as media: a compositional system for staging participation with reflective scenography*. Ph.D. Thesis. Caia, Planetary Collegium, Plymouth, UK: University of Plymouth

Tregenza, Peter & Loe, David (2014) (second edition) *The Design of Lighting*. New York: E & FN Spon, Routledge.

Voltelen, Mogens (1969) *Behygningslære*; kompendium fra forelæsninger. København: Kunstakademiets Arkitektskole.

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