

## Effect of Dynamic Responsive Lighting on Waiting Experiences in an Office Context

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### Abstract

*Responsive Environments can be defined as the environments enhanced with technologies that focus on information, media and communication and that are able to sense and respond to the users. The aim of this research is to determine the effects of dynamic responsive lighting as a medium on the experience of boredom in waiting rooms. The empirical research shows dynamic colored lighting has a positive effect on decreasing the experience of boredom and increasing the experience of relaxation in a waiting context. It is however not evident that by giving more control to the users, dynamic colored lighting would have more effect towards the flow experience.*

**Keywords:** *Dynamic Responsive Lighting, Design for User eXperience, Boredom, Flow*

### 1. Introduction

New lighting technologies such as LED and OLED offer new opportunities in lighting design. On one hand it offers possibilities for energy saving, on the other there are opportunities for luminaries to become integral part of an environment. Besides static lighting as widely used at the moment, LED and OLED technology are in particular suitable for dynamic and colored lighting solutions. Integration of luminaries in the environment has an impact on lighting design and lighting experience. Research in the past has already shown the positive effect of dynamic (non-colored) illumination in work environments on productivity and well-being of employees [1]. The responsiveness of these environments relates to the day time and changes brightness and color temperature instead of adapting to its users [1]. In perspective of Responsive Environments defined by Beesley et. al. [2], these environments are equipped with technology with a focus on information and communication as well as its ability to sense and communicate towards humans. Most of the current lighting environments are not responsive towards people. A next step is the research on the effects of dynamic responsive colored illumination on the User eXperience (UX) as a key element in the design process [3].

#### 1.1 Waiting rooms in office contexts

To study the effects of dynamic responsive lighting on UX, we selected the waiting experience in office contexts where boredom plays an important role [4, 5]. In other settings such as hospitals, other aspects such as anxiety, confusion or uncertainty influence the feeling of the user. In office waiting room contexts uncertainty is caused by the unknown waiting time, for which a number of solutions have been developed in a broad range. A more pleasing wait experience can be created by adjusting the interior although it mostly doesn't go further than proper seats, magazines to read, TV's, music and plants to decorate the environment. To lower the uncertainty, for example in city halls, number-ticket dispensers and displays may give the people an estimation of the waiting time, which has a positive effect on the waiting experience, also gives people the feeling of being helped in the right order [6]. It is certainly a design opportunity to improve the waiting experience using lighting solutions. Philips has developed a number of solutions to re-create the experience of a particular space. For example for entrance halls special lighting solutions are developed to create an atmosphere where people can adapt from bright light outside into the building [7]. These lighting solutions Philips presents mostly focus on healthcare and relate to experiences of people within a hospital.

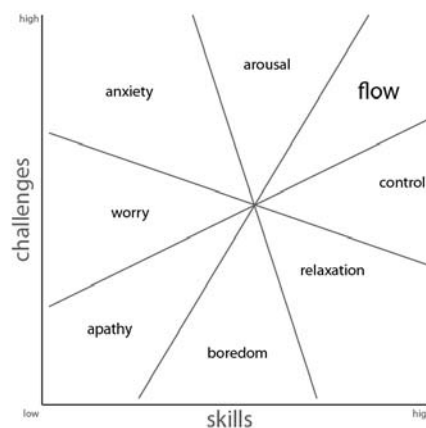
Although these lighting systems can be adjusted, most of them have to be controlled manually and do not respond to its environment. Philips for example created a lighting solution with which patients were able to create a light atmosphere so that they could feel confident just before undergoing a medical test. During these tests, patients need to stay calm and wait until the test is over. According to

Philips the possibility of adaptation has a positive effect on the experience of users: people didn't have to 'wait' as long as they used to [7]. However, all these systems are designed with one limitation in common: they are to be adapted by a single person and do not respond to its environment as such. Multi-user interaction is not well taken care of. In practice most of these systems use a remote control to change the settings of the dynamic lighting. An example is the Philips Xitanium controller [8]. The user provides the necessary input for the system, being the system not responsive to its environment but to react on a given input. It is interesting for Responsive Environments to go beyond the direct control using a single remote control, taking into account multiple people instead of one person having an influence on lighting. These examples show the new developments in health care settings with a focus on preventing anxiety in waiting rooms instead of fighting against boredom.

A lot of research has been done to decrease the feeling of the waiting time, however the waiting experience itself has not been a topic for discussion for a long time [9]. For example the effect of people having smart phones and being able to figure out something to do while waiting has not been researched yet. One could assume the presence of smart phones in waiting rooms may have a positive effect on fighting the boredom, although one could question the effectiveness.

## 1.2 Boredom

In 2009 research has been conducted to determine the possibilities of detecting boredom [10]. So far this has not led to concrete examinations of boredom. In literature there are numerous descriptions of different elements of boredom. Boredom is not related to some of states of low arousal, such as sleepiness [11]. According to Berlyne [12] boredom can be caused by a lack of arousal potential or repetitive (monotony) signals. Repetitive actions can lead to monotony and the lack of possibilities may lead to boredom [13]. This lack of possibilities forms an interesting link to another aspect mentioned by Mihaly Csikszentmihalyi who explains with his flow theory (Figure 1) [14, 15]. In the state of flow people perform tasks in an optimal balance between skills and challenge [14]. Later the lack of being in flow and its relation to boredom is mentioned by Lundberg et. al. [16]. Corresponding to the flow theory, the map of emotional by Wild et al. [17] explains boredom as an underload and anxiety (as perceived in hospital settings) being an overload. This underload of boredom can also be expressed by the environment itself: environments which lack changes and complexity are linked to boredom [18].



**Figure 1.** Map of the flow theory [14].

Boredom, or part of boredom, is caused by the awareness of passing time, which is mentioned by Maister [9] and also by James [19]. Similarly slowness of time is defined as one of the four measuring elements of boredom by Ragheb & Merydith [20]. The other three are lack of meaningful involvement, lack of mental involvement and lack of physical involvement. Besides these four elements social isolation can also be an important factor in causing boredom [21-24]. According to van Aart et. al. [11], there are a number of possibilities to arouse boredom:

1. Induce sensory deprivation by reducing the external stimuli people receive.

2. Create monotony by the use of predictive and repetitive stimuli.
3. Prevent drowsiness by the use of high intensity stimuli.
4. Prevent satisfaction of need for excitement.
5. Avoid changes, new unexpected happenings.
6. Don't mention the reason, duration of the wait and the wait at all.
7. Emphasize the awareness of time while waiting.

### **1.3 Research questions**

These researches about boredom form the basis for further research on the effect of dynamic responsive lighting on the experience of boredom. The research questions defined for this research were the following:

- 1: Does dynamic responsive lighting in a waiting room affect the experience of boredom?
- 2: If so, towards which type of experience does it affect people's experience in waiting rooms?

In this research we were interested in the responsiveness of the environment that came from the environment itself and was influenced by people and their movements in the environment. No remote control was used.

## **2. Design implementations**

### **2.1 Experiment setup**

Several experiments with people waiting in an office context waiting environment were designed to address the research questions. The experiments are not meant to create boredom in particular but to provide several normal situations in which boredom may be experienced. Three groups of participants were invited to the experiments. The first group was waiting in an environment with fluorescent tubes, in fact a 'common' waiting area, in the experiments being treated as the control group (CG). The second group was waiting under dynamic but non-responsive lighting (DNR) and the third group under dynamic responsive lighting (DR). Each participant was invited to the experiments only once.

Based on the literature study the expectation was that the CG setting was likely to provoke the boring experience as it lacks meaningful, mental and physical involvement. Lack of mental and physical involvement has been found to be contributing to the experience of boredom [27]. In comparison, the DNR and DR settings are likely to have more sensory activating effects due to the dynamics of the lighting and perhaps even provoke mental involvement in predicting the lighting patterns. The DNR setting is expected to provoke slightly more boredom than the DR setting as the DNR lighting patterns are more repetitive and predictable, involving no changes at all over time [11]. The DR setting may have an effect on physical involvement: people being attracted to interact with the lighting setting through movement. As stated before, the question is whether dynamic lighting has an effect on the mental and physical involvement and in the end have an effect on the experience of boredom.

### **2.2 Pilot experiments**

Three pilot tests were done to determine the further scope of the research with respect to the activities of people in waiting rooms as well as their gestures as possible input for interaction, and to capture their first impressions of a dynamic responsive waiting room. Each pilot experiment represented one of the situations of CG, DNR and DR. Unlike the aim of the final experiments later, participants were informed about the goal of the experiments and were aware that the waiting experience is the key element under investigation.

#### **2.2.1 Procedure**

Three male students (age between 18 and 23) were invited to participate in the experiment which took place in the room called Breakout 404 (HG Building, Eindhoven University of Technology (TU/e), Figure 3). The experiment setup consisted of the standard breakout space: no adjustments for the experiment had been made. For these pilot experiments, the participants were asked to wait in the

space before an interview about waiting room experiences. The waiting time was 15 minutes but no indication about the duration of the waiting time was given in advance. During these experiments, participants were observed via a webcam connected to a computer for observation on the gestures and activities. The participants were informed about the observations before the experiment started. For all experiments, the participants were alone in the space with the aim to provoke boredom and had no opportunity to socialize with fellow students. Social isolation has been determined to have an effect on creating boredom [21-24]. After the waiting time had passed, the experimenter entered the room and a semi structured interview took place to obtain a broad view on the waiting experience.

## 2.2.2 Results

To analyze the results from the observation and the interview, an approach by Taylor-Powell & Renner [25] was used to structure the information and sort out most important insights: The recorded interviews were transcribed for detailed analysis. This step makes it possible to do early identification of lightning themes or which lighting themes might be relevant for the waiting experience. As each pilot experiment was conducted under a different lighting setting, the data can be compared for each of the questions to give an indication of different experiences in each of the settings. After transcribing the data, all answers have been checked for information related to the research questions. Each relevant term in the answers of the transcripts was coded, e.g. participants in the DNR and DR setting suggested that they felt “relaxed”, and the experience is coded as RE accordingly. This step led to a number of relevant terms which came back once or more throughout the interviews. This step was followed by identifying possible themes with related term codes within these themes. The themes found were the feelings which participants reflect on, interactions with the space which contains the movements, and perceptions of the participants with respect to the dynamic lighting. The last theme is related to the environment perception how the participants experienced the environment and how would expect to experience in a waiting room.

How people feel is mostly about the descriptions of participants how they assessed their own feelings (e.g. relaxed, slightly bored, neutral). The term “calm” was explicitly mentioned in connection with the dynamic light patterns. All participants mentioned the feeling of being alone. Some experienced stress, which was caused by the fact the lighting conditions are not optimal for what they were doing or wanted to do, as explained by them. During the pilots, participants tried to find something to do, for example, sketching, writing, listening to music, of which some activities were negatively affected by the dynamic lighting conditions (e.g., DNR and DR). Participant in the CG did not mention such difficulties, since they were under static white fluorescent tubes.

Interaction theme included the terms which were related to the movements of participants and their connection with the waiting environment. For the DNR setting, the dynamic lighting patterns were chosen randomly. For the DR setting the dynamics changed accordingly to the participant’s activity, in which the participant confirmed that he experienced the influence of his movements on the lighting pattern. The interaction was also related to the connection towards the environment: the participant of the DNR setting explained he felt neither connection to the environment nor possibility to influence the lighting pattern during the experiment, but suggested what the system could have offered the connection and the possibility during the interview. For dynamic and responsive lighting, the need for the need for the user being aware of the fact the environment is responding to him is in line with the findings of Krueger [26].

Perception theme solely focused on the experience of the lighting patterns. For the participant in the control group, the participant perceived the lighting to be boring and too bright. By contrast, it was interesting that both participants for DNR and DR recalled the dynamics to be soft, subtle and gentle, but getting stronger over time. These two participants also talked about atmosphere: the red-orange patterns were seen as something warm and cozy (one of participants called this a ‘fire place’) while the green-blue pattern was considered to be calm and relaxing. Participants of all settings remarked the experiment environment to be quiet in which they felt lonely. With respect to the connectedness to the environment it could have been more explicit, to invite people to interact with the environment, thus influence the dynamic lighting patterns for the DNR setting.

The pilot experiments led to a general observation of what people experience and do in waiting rooms: the tendency to search for activities to do something. In that perspective, boredom could be

prevented from occurring because people search for activities to take away boredom before it might be experienced. Nowadays it is likely people will use smart phones while waiting in order not to get bored.

It seemed to be necessary to take away all electronic devices to make sure people will have a chance to experience boredom, not being distracted from the waiting experience. Taking away the influence of such devices could provide more reliable observations on the waiting experience. However one could suspect that such an experiment setup does not match the real life situations.

The dynamic patterns of the light had calming and relaxing effects on participants. This formed the input for further design of the DNR and DR experiments.

### 2.3 Design implementations for final experiments

Results of the pilots, especially those with respect to relaxation, were used to fine tune the setup for the final experiments. CG was perceived to be most boring setting of all three, which could be utilized as the base line of boredom. The DNR setting was adjusted to create relaxation within the waiting area. The same setting for relaxation was also used for the DR setting for the moments participants were about to sit around not moving at all. The added value of the DNR setting was to bring participants from relaxation into flow by increased challenge (Figure 2). In addition, Flow Theory implies being in flow having the effect of being unaware of passing of time [14]. Taking into consideration the awareness of time is partially responsible for creating boredom [8, 11], being in flow should have an added value in fighting with boredom.

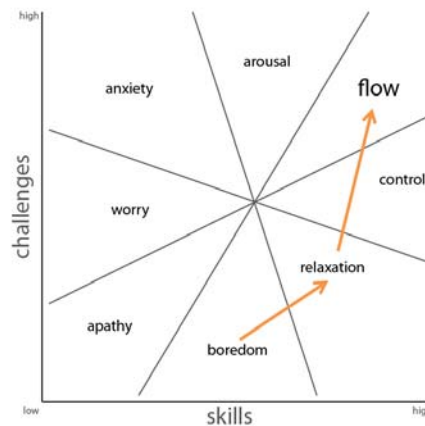


Figure 2. Map of flow theory [14] and the intended improvement towards relaxation in DNR and flow in DR.

## 2.4 Final experiments

### 2.4.1 Experiment setup

A new experiment setup was designed according to the observations from the pilots and the research purposes, using the fully equipped office space with dynamic and static lighting in Breakout 404. The dynamic lighting consists of full color LED wall washers and pre-installed full color LED accent lights on the wall. For general lighting three incandescent lamps were installed above a table in waiting spot of the room. On the other side of the room two halogen standing floor lamps provided additional lighting (Figure 3). The lights were controlled wirelessly via a specially designed app on an Android tablet (Figure 4). Connecting smart devices in such an responsive environment has become a common practice [27-29]. The app allows selecting presets of static and dynamic lighting patterns, and adjusting color brightness, variation, and the speed of variation. The Wizard of Oz approach [30] was used to create a making-believe real life situation [31], especially for responsive lighting.



Figure 3. Breakout 404 - Experiment room. Picture shows the side of the waiting room with incandescent lamps and full color LED wall washers where participants were asked to wait.



Figure 4. An Android tablet is used to control the dynamic lighting settings from outside the experiment room via a wireless network.

The final experiment setup contained the same three groups of participants as in the pilots: The first group is the control group (CG) which had to wait under white light provided by fluorescent tubes on the ceiling. The second group was asked to wait under dynamic, but non-responsive lighting (DNR) and the third group under dynamic responsive lighting (DR). These three groups were again necessary to determine the effects of the responsiveness on the experience of boredom and to indicate the differences in the perspective of the flow theory (Figure 1). The DNR setting consisted of slightly dimmed incandescent lamps and red colored wash lights on the walls, varying between red and orange to create a warm, cozy and relaxing environment. The brightness, variation and the speed of variation of lighting for the DNR and DR setting are fixed using the tablet controller. For the DR setting, one additional change was made by the color change between red-orange (passive/not moving state) towards blue-green (active/moving state) to underpin the natural feeling of activity [32]. The high contrast between red-orange and blue-green settings has been chosen to create a clear distinction the states of participants moving or not moving to communicate the responsiveness of the environment. This to imply the possibility for participants to interact with the environment and create opportunities to challenge the participants by provoking curiosity: what happens if I move around the environment? Participants needed to become aware of the fact that interaction was possible before interacting with the environment, as the precondition for responsive environments [26]. The awareness of the responsiveness of the environment should come from the environment itself rather than being informed when entering the room [26]. In the DR setting, the participants were challenged with their curiosity to discover the lighting functionality of the environment, which was expected to bring the participants into flow. The lighting setting was designed for the UX as supported by Hassenzahl [3] rather than design for pure functionality and usability.

The participants were invited to “an experiment of touch screens”. When they arrived at the Breakout 404, they were asked to wait, without knowing that waiting has already being part of the experiment. The participants were observed via a camouflaged webcam installed in the waiting room with prior notice (of the “touch screen experiment”). Their gestures formed input for the DR setting through the Wizard of Oz approach. A controller changed the lighting setting from red-orange towards blue-green in case of changing from sitting towards an activity of the participant (e.g. checking the drawer in front of the seats). In other cases the participants were observed to determine whether they would react on the light or not as additional data next to the interviews and analysis. The webcam observations were also to determine whether participants used their smart phones or checked the passing time on for example their watches, although they were asked politely not to use or wear these items.

#### **2.4.2 Participants**

The participants for the final experiments were students from the department of Industrial Design at TU/e. They were explained that the experiment involved a period for acclimatization, the touch screen experiment and an interview afterwards. Only staff and students who were not informed about the research were selected. Sixteen participants joined the experiments in three different settings: CG (n=5), DNR (n=5) and DR (n=6). The participants (11 male and 5 female) were between 19 and 26 years old. All participants were Dutch native speakers who can speak fluent English. None of the participants is (partially) color-blind. Each participant could participate in one experiment setting only, preventing pre-knowledge which may affect the data.

#### **2.4.3 Procedure**

Before the touch screen experiment – which is actually a fake experiment, participants were informed about the exact procedure of the fake experiment. Participants were informed about a required period of acclimatization to obtain usable data from the experiment. Participants were not informed about the actual experiment about the waiting experience.

First a 10 minute period of acclimatization was before the touch screen experiment would take place. No indication of the length of the acclimate period was given to any of the participants, to prevent them from forming a view on the waiting time, affecting the experience of boredom as mentioned by van Aart et. al [11]. Participants were also asked not to use any electronic devices while acclimating in the room as it might lead to mental and/or meaningful involvement which affects the experience of boredom [20].

Leaving the participant waiting, the experimenter left the room with the excuse to have something to print out for the experiment. The experimenter actually observed the participants waiting via the webcam, and in the DR setting, controlled the dynamic lighting in responding to the participant’s movements and activities. Figure 5 shows webcam screenshots of different settings (CG, DNR and DR).



Figure 5. Screenshots of the webcam observing participants in (left-right/top-down) GC, DR, DNR, DR settings.

After the period of acclimatization the experimenter came back and checked if everything went well for the participant. The experiment followed by playing the two levels of Angry Birds game [33] on an iPad and an iPhone, and typing a sentence in a text processing app on both devices without using the backspace key. The duration of the fake experiment varied between 5 and 7 minutes.

After the fake experiment an interview followed, for which participants were asked their permission to record. After the recording started participants were informed about the fact that the time they spent waiting was the actual experiment. This made it possible to capture the first reactions.

#### 2.4.4 Interviews

Semi-structured interviews were conducted to review the participants' waiting experiences now and in the past, the experience of boredom and the experience of the lighting settings. The semi-structured interview was conducted instead of questionnaires because the test is about UX of which the data contains real life experiences. Many questionnaires regarding boredom have been developed in the past, although none of them is suitable for the context of this research as they address unrelated topics [20, 21, 34-38]. In addition a number of topics were to be rated by the participant on a 7 scale as control and additional data. After the interview the participants received more information about the actual research, the experiment setup and the aim of the research. Duration of the complete test including interview was about 30 minutes.

### 3. Results

#### 3.1 General

Qualitative data analysis developed by Taylor-Powell & Renner [25] was followed. The analysis showed that half of the participants in all different experiment settings indicated that they were waiting alone in the space (CG n=3, DNR n=2, DR n=3). Only one participant in the DR setting mentioned the possibility of influencing the lighting by his movements. The furniture was remarked by participants in all groups, however all participants of the DR group (n=6) remarked the furniture to be nice (fijne meubels) in contrast to the DNR group (n=4) and CG (n=2).

A general trend of participants in this group is the use of smart phones while waiting in general, but not during the experiments since they were asked not to. All participants possess a smart phone (n=16) and most of them indicated they used this kind of electronic devices to 'fight the boredom' while waiting (n=15). Activities of using a smart phone varied from listening to music, calling, instant messaging (e.g. whatsapp), social media (e.g. facebook, twitter), browsing internet (e.g. reading online news), checking emails to a combination of these activities.

#### 3.2 Control Group



Participants in the control group expressed feelings of being bored (n=5). They also rated an average of 6.2 out of 7 on scale of boredom, which showed CG experienced boredom the most.

The fluorescent tube lighting was described in different ways by the participants. Ugly, boring, office lighting, storage room lighting were all explained as negative associations with the lighting by the participants.

Participants of this group were also asked about the feelings of being able to control/influence the lighting setting. None reported having the feeling. The only influence this group mentioned to have is to adjust the physical space (e.g. moving the seats).

The estimated waiting time for all CG participants was between 10 and 15 minutes. Two of them mentioned they became impatient while waiting (n=2). One of them mentioned to feel stress because of another task to complete in that afternoon but he was kept waiting.

### **3.3 Dynamic Non Responsive**

Differences could be identified in the second group of participants waiting in a dynamic but non responsive setting (n=5) regarding experiences of boredom. Three participants expressed no feeling of boredom during the waiting time. Two participants said to be slightly bored but not that much. The average rating was 3.8 out of 7 concerning boredom. Three participants mentioned feelings of relaxation (n=3), in addition one participant mentioned to be calm. One participant in this group was not immediately aware of the fact the lighting slowly changed over time until the moment she was asked to talk about the lighting setting. The presence of colored light was commented by all participants as a difference from the waiting experiences in the past.

The average estimated the waiting time of this group was between 5 to 10 minutes.

### **3.4 Dynamic Responsive**

Participants of the DR setting (n=6) rated their experience of boredom even lower compared to the CG and the DNR group (2.5 out of 7). None of the participants in this group explained feelings of boredom during the interview. All participants in the DR setting mentioned feelings of relaxation.

The changes of the lighting over time were mentioned by all participants in this group. However, only one participant was aware of the fact that his movements influenced the dynamics of the light, although he explained the awareness came relatively late just before the experimenter came in. The other five participants were, alike the CG and DNR groups, not aware of any possibilities of controlling/influencing the light by movements.

The average waiting time estimation of the DR group was 6.5 minutes. Besides, the answers concerning the estimated waiting time were rather concrete and expressed in one integer number.

## **4. Discussion**

The results in three different settings have shown a clear difference between the experiences of boredom in different waiting rooms based on the ratings and expressed feelings of boredom in the interviews.

A general base line for boredom to exist in all experiment settings was the duration of the waiting time was not given to any of the participants in advance [11]. As derived from the literature, social isolation in form of being alone forms an opportunity for boredom to arise as well [21-24]. However, only half of the participants in all settings expressed loneliness. The effect of social isolation in relation to boredom could not be underpinned with the experiments.

Participants in the control group experienced boredom the most while waiting, according to the average rating of boredom of this group (6.2/7) and the expressed feelings of boredom. The participants of this group estimated a waiting time between 10 and 15 minutes, which is the longest among all three groups, indicating the possible awareness of slowness of time, as considered one of the aspects of boredom [20]. Boredom could be also aroused by the lack of sensory stimulation: no changes in the environment were made during the experiment.

The DNR and DR settings led to lower ratings of boredom (3.8 and 2.5 respectively) and boredom was mentioned less in these settings (DNR n=2) or not at all (DR, n=0). In these two settings, feelings

of relaxation were explicitly mentioned. The DR setting showed most experienced feelings of relaxation (n=6) comparing to the DNR setting (n=4). Also in these cases participants perceived relaxation (DNR n=4, DR n=6), no boredom or only slightly bored (DNR, n=2).

It was also expected for the DR group to get away from relaxation and to experience flow, since they were challenged to discover the responsiveness of the environment. However, no clear indication of the flow experience comparing to the DNR setting could be found in the experiments.. This may be caused by the fact participants in the DR group in general were not aware that they were able to influence the light settings themselves. It could be that unawareness of interaction possibilities cannot provoke intended interaction in responsive environments [26], blocking possibilities of challenging people. This might imply the need of future research focusing on the duration of the wait and the moment people become aware of the possibilities to interact with the environment. Thus, the lower rating of boredom in the DR (2.5) setting compared to the DNR (3.8) cannot be justified by the added value of interacting with the light settings as participants were not aware of the possibilities to interact. A possible explanation for the lower experience of boredom may be caused by the changes in dynamic patterns with respect to color, providing more changes with a higher contrast and breaking the expectations of the pattern. This is in line with the repetitive and predictable patterns in relation to boredom as described by van Aart et. al. [11]. In addition, color changes between red-orange and blue-green form a moment of unexpected happenings which is also considered to prevent boredom [11], especially when the person is not aware of the possibilities of influencing the lighting.

The feeling of relaxation seemed to form a general experience in the DR settings, which is considered to be a different experience away from boredom [14]. This has been the intention for the DNR setting although the DR aimed to have added challenge which could not be underpinned as explained. The fact that participants in the DNR and DR groups used the waiting time to relax may imply a meaningful involvement, although this cannot be derived from the gathered data. Lack of meaningful involvement is considered one aspect of boredom to exist [20]. From this perspective relaxation as meaningful involvement may be used to fight the boredom.

Another indication for the difference in experience of boredom may relate to the estimated waiting time. The estimated waiting time was clearly higher for the CG (10-15 minutes) in comparison to the DNR group (5-10 minutes) and DR (average of 6.5 minutes). the awareness of passing time is considered to be one of the factors causing boredom [20], which was clearly observed in the CG group that estimated the waiting time below the actual passed time of 10 minutes.

## 5. Conclusion

In general it can be concluded that the dynamic colored lighting has a positive effect on decreasing the experience of boredom in the office-like waiting contexts. The experiment results show that dynamic lighting may shift the experience from boredom towards relaxation. It was not evident in our experiments that the responsiveness of dynamic lighting could shift further the experience towards flow. As discussed this may relate to the awareness of the possibilities, and the duration of the waiting time to be long enough for the participants to discover the possibilities, which is yet to be further investigated. The use of colored patterns may also form a possibility for future research. Although the responsiveness was not proven to be effective, the variation in the lighting pattern led to different results. The use of patterns with higher contrast may have a positive effect on decreasing the experience of boredom.

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