

**Zumtobel Research**

Attention equivalent – a study concerning the effectiveness of specific lighting parameters on the perception and preference of customers in a shop

Prof. Jan Ejhed, Royal Institute of Technology in Stockholm | SE (KTH)

Prof. Dr. Roland Greule, HAW Hamburg | DE

Markus Felsch, Felsch Lighting Design, Hildesheim | DE



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Tommy Hilfiger, Paris | FR

The study is intended to demonstrate the correlation between the brightness, light distribution, light colour and the combination of these factors on the attraction and purchasing behaviour of customers in a shop. In general, the study deals with an application that is primarily judged to be very individual, brand-related and emotional. This is why a scientific survey of data is very difficult. The aim is therefore to use methods from which perception and behaviour mechanisms can be derived and that can also be translated into indications to support lighting planning.

So far, the philosophy that the brightest shop attracts the most attention is still very popular, but due to current energy guidelines a simple increase in illuminance levels within a shop is no longer practical. Thus alternative measures are searched for in this study that have the same effect on attention with lower consumption of energy.

# Short Summary

The most important findings: it is not all about brightness. Contrasts, i.e. the effect of light and dark areas, are decisive. Customer behaviour in retail areas is significantly influenced by perception and a sense of well-being. Light is an important design tool which impacts these parameters, because light conveys emotions, lends spaces atmosphere and makes it easier for people to find their way around.

Zumtobel's latest applied research is devoted to the topic "Attention, attractiveness and perception mediated by lighting in retail spaces". Zumtobel conducted a two-part study in cooperation with Prof. Jan Ejhed, head of the lighting laboratory at the Royal Institute of Technology (KTH) in Stockholm, and Dr. Roland Greule from the Hamburg University of Applied Sciences (HAW).

The purpose of this investigation was to determine the factors that are decisive in shop lighting when it comes to selling more merchandise, increasing the number of customers who enter a shop and extending the amount of time they spend there.

## Research design – Perceiving light

The first part of the study was based on the question of the extent to which lighting influences customers' subjective perceptions. In order to establish the kind of lighting situations that people prefer in shops and retail spaces, 97 test subjects were asked to directly compare and assess three lighting situations in virtually displayed shopping situations.

The second part of the study consisted of laboratory research and a field study in cooperation with Dr. Roland Greule and Felsch Lighting Design, in which the perception of the test subjects in retail spaces was examined with reference to previously defined lighting parameters. The lighting factors that were to be investigated included light colour, light distribution, lighting intensity and dynamic changes in brightness or colour. Laboratory tests using test charts produced generally valid statements regarding visual effects such as contrast and colour perception. The laboratory results were then compared with real retail space situations. A Douglas perfume shop and a supermarket operated by the Austrian SPAR chain were used for the field projects. An eye-tracking camera system was used to capture subjects' eye movements using modern measuring instruments.

**Results – the sense of well-being must be improved**

To recap the results of the investigation, it yielded technical lighting design principles that are especially insightful as far as the work of professional lighting designers is concerned. Prof. Jan Ejhed sums it up: "The study is a valuable resource and sets out key factors that should guide lighting design in shops and retail spaces. The result of this study shifts the focus of future lighting design; it shows the need to do more than simply attract the customer's attention, and identifies the need to devise a new approach that will improve customer convenience and enhance the customer's sense of well-being." Zumtobel Marketing Director Stefan von Terzi explains: "This new Zumtobel study provides valuable information that can be used to develop lighting solutions and their applications in the shopping and retail sector. Thanks to our in-depth knowledge of this application area and awareness of the needs of users and the effect of light, we are in a position to develop innovative lighting systems that create measurable added value for our customers."

# 1 Problem definition

## 2 State of science

### 3 Research hypotheses

#### Problem definition

For many years it was assumed that increasing the brightness of a shop window or a shop was accompanied by an increase in the attention of passers-by. A direct correlation between illuminance levels and attractiveness could be proved. But this need today strongly contradicts current energy efficiency requirements. Now new ways have to be found that have just as high an effect on the attention of potential customers. The aim of this study is to find an attention equivalent for the brightness of the retail space lighting and to analyse which factors in shop lighting are decisive for achieving a greater influx of customers into shops, for these to stay longer and to also finally decide on the purchase of goods.

#### State of science

Many studies concerning perception psychology justify the arrangement of goods and analyse general viewing behaviour during a purchase process. Hardly any study shows the effect of individual lighting parameters on the purchase behaviour and length of stay of customers. The study explained below leads to new findings in the area of retail application research.

#### Research hypotheses

The study is intended to demonstrate that not only the brightness of a shop window or a shop is decisive for its level of attraction. Less is sometimes more. As such, precisely implemented accent lighting can create focal perception points and attract the attention of observers. In addition to attractiveness, however, two further important factors for turnover and customers' length of stay in a shop are well-being and simple orientation. Both can be achieved by horizontal lighting in addition to vertical accent lighting.

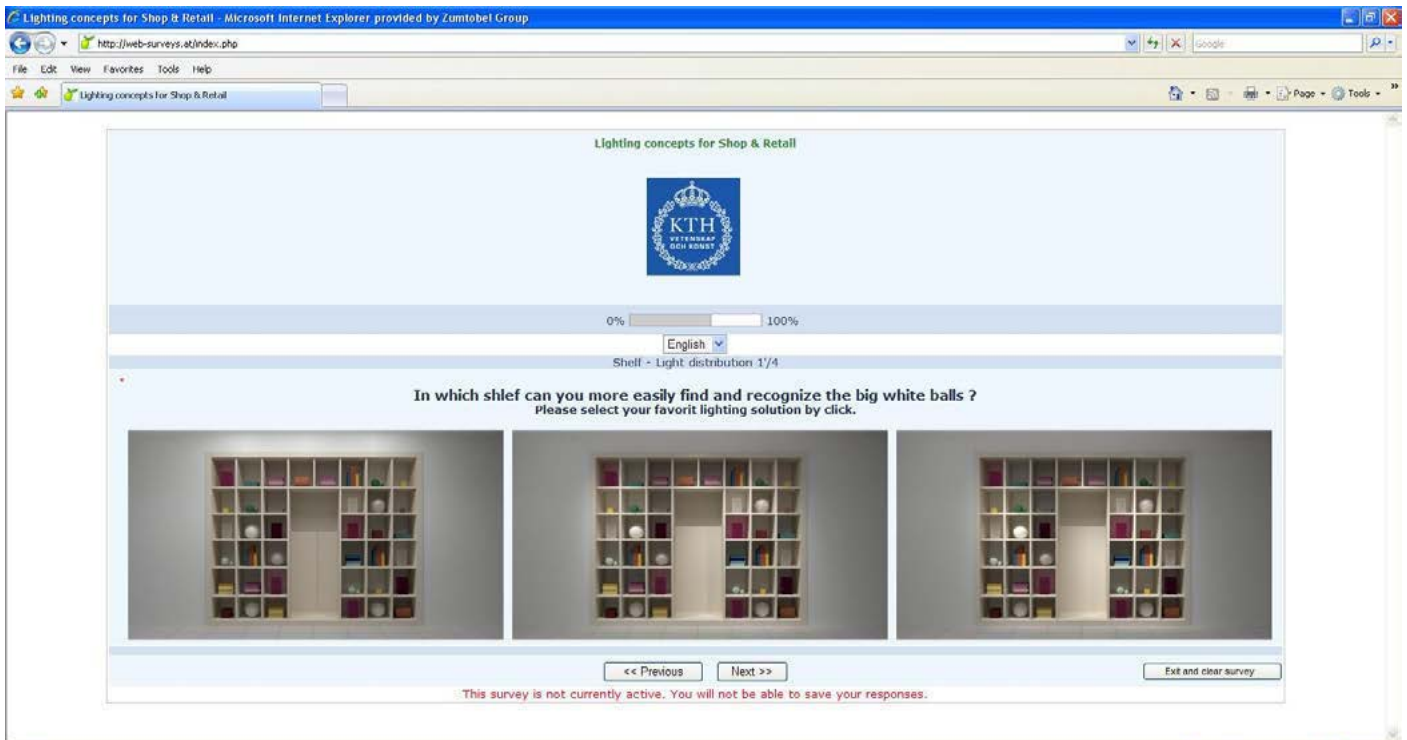
- What influence does the lighting have to achieve this effect?
- Which factors and combinations of factors create the effect?
- Is there a difference between preference and attention with the various factors?
- Are there different preferences for different target groups (type of customers / lifestyle)?
- Is there a correlation between the weather / times of the year and the preference or attention?
- Is the preference / attention different for different objects / materials / interior design?
- Is there a difference for preferences with different perspectives or zones in a shop? (distances)



The research project was split into several sub-sections and various methods were applied.

### 4.1 Online survey

#### 4.1.1 Selection of methods



An online questionnaire was drawn up to initially gain the preferences or subjective judgement of customers. The benefit of this questionnaire was that a large number of test subjects could be reached internationally and flexibly. The results could be simply exported. The online questionnaire is based on the subjective comparison of various lighting solutions, and these solutions could be interactively optimised or evaluated. Simple lighting parameters such as brightness, colour temperature and light distribution were varied or visualised within the lighting solutions.

The following types of questions or scales were used:

- Selection question (e.g. "Which of the three lighting solutions do you like the most?")
- Rating scale (e.g. "How satisfied are you with the lighting solution?")
- Setting (e.g. by selecting optimum light distribution via manual adaptation)

## 4.1.2 Test setup

Visualisations were used for evaluating the various light situations. Three different perspectives were used here:

- Shop windows, as the decision is made here whether to enter the shop or not
- Spatial perspective of the entrance that has a decisive influence on orientation and finding one's way around the shop
- Shelf perspective, as it is here that the actual purchasing decision is made

In order to eliminate as many influence parameters as possible, the analyses were carried out using relatively abstract objects. This means the brand effect is disregarded to the greatest possible extent.



The materials and the saturation of colours were varied as well. Shiny, transparent or matt surfaces allow evaluation with a focus on the lighting effect.

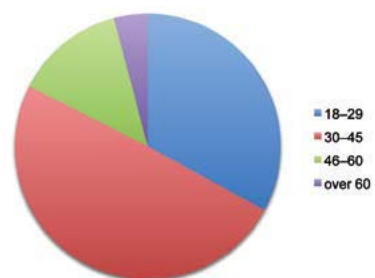
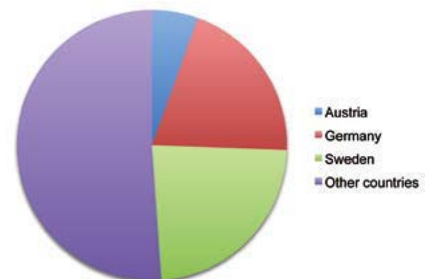
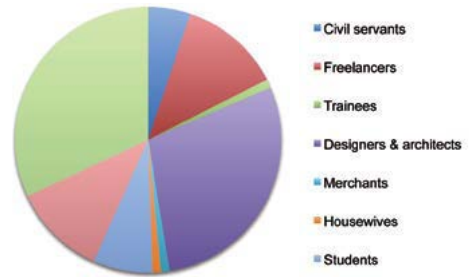
### 4.1.3 Test subjects

97 people from all over the world took part in the survey. Around half of the test subjects were female, the other half of the participants were male.

Occupation:	Civil servants	5
	Freelancers	12
	Trainees	1
	Designers & architects	28
	Merchants	1
	Housewives	1
	Students	7
	Other	11
	Active in the lighting industry	31

Countries:	Austria	5
	Germany	18
	Sweden	21
	Other countries	53

Age:	18–29	32
	30–45	48
	46–60	13
	over 60	4



## 4.2 Eye tracking

After the online survey, perception via an eye-tracking process was evaluated. Here the project was once again split into two sub-sections: laboratory analysis and field trial.

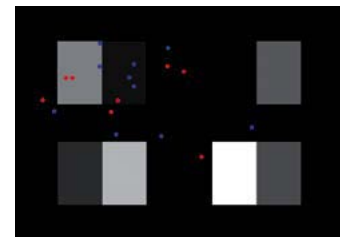
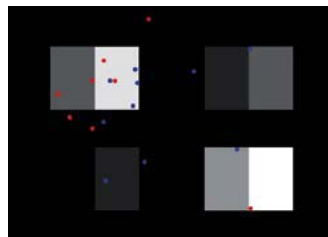
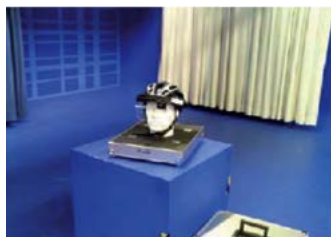
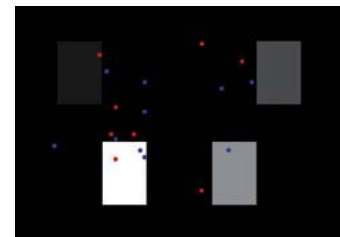
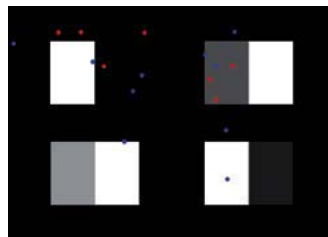
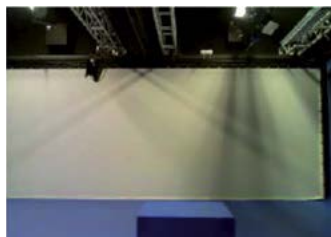
### 4.2.1 Laboratory analysis

#### 4.2.1.1 Selection of methods



At first the perception-theoretical approaches were analysed in a laboratory study and without the influence of other parameters. Test charts were created that reflected the fundamental principles of perception.

The test charts were created as graphics and flash animations and embedded in an overall PowerPoint presentation. The test stimuli were always shown on a black background.



Only the "first glance" of the specific test subject was considered for all test charts with static contents. For evaluation of this first glance, the coordinates on the slide were determined where the test subject first looked immediately after a new slide appeared.

With the dynamic modifications, it was determined which change was recognised first and how much time this recognition took from the beginning of the slide.

### 4.2.1.2. Test setup

The laboratory analysis took place in a completely darkened test room with a floor space of 7 x 7.9 metres. The room is used by the university as a television studio for blue screen recordings and can be used as a virtual studio. This is why this room is very dry in terms of audio technology. Illuminance at the position of the test subject was less than 1 lux in the darkened room.

The projection surface was at a distance of 6.1 metres from the test subjects, had a width of 2.6 metres and a height of 1.8 metres. The beamer LP 530 (DLP) from the manufacturer InFocus with 2000 ANSI lumens was used for projection purposes. The beamer was centrally positioned in front of the projection surface, as were the test subjects.

All relevant values of the test charts were measured with the Minolta Chroma Meter CS-200, and both the luminance and colour values (XYZ, with x, y, Lv for position finding in the CIE colour map) were determined with this measuring device. Measurements were taken from the position of the test subjects, and the measurement point was in each case centrally in the object or area to be measured.

The eye tracking system "iView X HED" by SMI (SensoMotoric Instruments) was used to track and determine eye movement. The following specifications were used:

- Non-invasive, video-based eye tracking / Monocular, pupil-CR, dark-pupil tracking, Sampling rate eye movements 50 Hz (optional 200 Hz) / tracking resolution < 0.1° (typ.), Gaze position accuracy < 0.5°–1° (typ.)
- Workstation Tablet PC or laptop, Operating system Microsoft® Windows XP™
- Mobility Package Extra batteries, external charger, 12 V car adaptor, backpack
- Lightweight, comfortable, quick & easy to adjust bike helmet, baseball cap, headphones, flight helmet, and headband mount available / interface weight 79 g / cable length 5 m or 2 m
- Digital scene video recording in broadcast quality (MPEG-4), Audio channel recording (optional) / Open platform communication interface (UDP)
- Integrated video analysis software – SMI Video Analyzer™ / compatible with 3rd-party video analysis packages (e.g. The Observer™ from Noldus)
- High-speed eye tracking option (200 Hz)
- 6D head tracking option for numerical recording of gaze position in complex environments (e.g. simulators, CAVE)

To keep the framework conditions for all test subjects as identical as possible, measurements were carried out in a tightly scheduled, consecutive sequence over two days. The test subjects were all given the same predefined instructions to keep influences from the method of instruction low. Finally, the presentation of the charts was completely identical for all test subjects. In the test presentation, the test charts were shown for a predefined time that was the same for all test subjects; the transitions between the test charts were the same as well.

### 4.2.1.3 Test subjects

19 test subjects participated in the test. From these, eight were female and eleven male, at an age of between 22 and 58 years.

## 4.2.2 Field trial

### 4.2.2.1 Selection of methods

In the second phase, measurements in realised projects were implemented in order to transfer the findings gained from the laboratory study into practice.

The measurements carried out in the Douglas and SPAR shops primarily referred to a localisation of the “points of attraction”.

The measurements follow the intuitive orientation of the test subjects in the space. The SMI eye tracking system “iView X HED” was used for measuring as for the other measurements.



## 4.2.2.2. Test procedure

Specifications for the field test process:

### Test duration

Total duration per test subject:	22–25 minutes
Explanation:	5 minutes
System setup:	8 minutes
Test run:	4–7 minutes
Saying good-bye:	5 minutes

The test subjects were given a short introduction of the intended test and were informed about how to behave during the test. Then the eye-tracking system was set up for the specific person. The test was started after calibration of the system.

The test subjects were given the task of choosing a pair of glasses for themselves, if possible with frame arms of wood. The task was intended to increase the subjects' attention while viewing. The test subjects were not given any other instructions, and the duration was also not limited.

### Evaluation

Evaluation was carried out graphically. The "gaze positions" of the test subjects were transferred point-for-point into a graph of the room observed. The single points in the sequence of their observation were connected with lines so that the sequence of the observation could be recognised in the evaluation.

The gaze positions of the female test subjects were marked with red circles and the gaze positions of the male test subjects with blue squares.

### 4.2.2.3. Test subjects

The group of test subjects has the following composition for the field test:

	TS 1	TS 2	TS 3	TS 4	TS 5
m/f	f	f	f	f	f
Age	27	25	27	30	28
Glasses	y	n	-3/-4	n	n
Impaired vision	n	n	n	n	n
Favourite colour	none	green/blue	green	green/blue	blau
L/R-handed	r	r	r	r	r

	TS 6	TS 7	TS 8	TS 9	TS 10
m/f	m	m	m	m	m
Age	31	24	27	25	-
Glasses	n	n	n	0,75/0,5	-
Impaired vision	n	n	n	n	n
Favourite colour	black	black	blue	blue	-
L/R-handed	r	r	r	r	r

	Number	Age	mean age
Women	5	25-28	27.4
Men	5	24-31	26.3
Total	10	24-31	26.9

The test was carried out during normal opening hours and normal shop conditions. The framework conditions for all test subjects were generally identical, meaning the same shop, the same instructions and the same task. Specifically differing conditions may have occurred resulting from the varying frequency (visiting) of the shop during each test implementation. These were all a part of "normal" shop business and thus supported the analysis of behaviour of the test subjects during "normal" shopping.





## 5 Results

Previous findings claiming that maximum possible brightness in a shop increases attractiveness could be refuted. Instead, the study demonstrated that the most difficult visual task, i.e. the largest contrast concerning the visual task, influences its detection and attention. Perception of contrast depends here on the ambient brightness. The brighter the surroundings, the more marked the contrast must be. Even small differences in luminance levels are effective in dark environments.

It was also shown that vertical illuminance levels support orientation in the space and that simple orientation supports the decision to enter a shop. Here considerable differences in the evaluation of men and women became apparent. While men view a retail space more extensively in its entirety, women look at a retail space more intensely and in greater detail.

Supplementary horizontal illuminance increases the preference and well-being of the user.

The light distribution depends on the lighting's character. Goods have a more attractive and exclusive effect when light is focused on them more precisely and in more detail.

Stimulation via accent lighting, but also by backlighting the lower third of a shelf, leads to higher perception of this area, resulting in an extension of the amount of time customers stay there and in higher turnover.

The results specified here are only an excerpt from the complete documentation.

To recap the results of the investigation, it yielded technical lighting design principles that are especially insightful as far as the work of professional lighting designers is concerned. Prof. Jan Ejhed sums it up: "The study is a valuable resource and sets out key factors that should guide lighting design in shops and retail spaces. The result of this study shifts the focus of future lighting design; it shows the need to do more than simply attract the customer's attention, and identifies the need to devise a new approach that will improve customer convenience and enhance the customer's sense of well-being." Zumtobel Marketing Director Stefan von Terzi explains: "This new Zumtobel study provides valuable information that can be used to develop lighting solutions and their applications in the shopping and retail sector. Thanks to our in-depth knowledge of this application area and awareness of the needs of users and the effect of light, we are in a position to develop innovative lighting systems that create measurable added value for our customers."



## Summary of results – eight design recommendations

(1) Instead of increasing brightness in shops and therefore also energy consumption, it is advisable to design lighting that is always high in contrast, making perception easier and heightening levels of attention. Pinpoint accent lighting that stands out positively from the surrounding homogeneous ambient lighting is a suitable way of creating contrasts.



(2) Diffuse general lighting ensures a subjective sense of well-being. Vertical illuminance makes orientation easier in a room. The easier it is for customers to find their way around, the more likely they are to walk around a shop. Efforts must therefore be made to use vertical lighting to delimit the periphery of a space. At the same time, detailed accent lighting must be used to improve the perception and attractiveness of the goods displayed.



(3) Colours convey emotions and influence the acceptability of a space. The study results showed that cool colour temperatures such as cool white make areas appear more spacious whereas warm colour temperatures create an impression of smallness and familiarity. Intermediate white light extends the amount of time customers spend in a shop and improves their sense of well-being, and should therefore be used for general lighting. Anyone who prefers a shop atmosphere that makes customers feel safe and secure should opt for warm white light colours.



(4) There is a preference for various light colours within a single lighting concept. Different colour temperatures should therefore be consciously deployed across general lighting and vertical lighting. The latest Tunable White LED luminaire technology makes it possible to obtain colour temperature changes using control systems, and deserves special consideration in this respect.



(5) There are differences in perception depending on gender, age and groups of buyers: men take in a broad overview of a retail space, for example, whereas women look at details. It is therefore important to adapt the direction of light, light colour and lighting intensity dynamically over the course of the day to make sure it is appropriate to the target group's behaviour.



(6) Shop windows are often the customer's first point of contact with a shop: accent lighting on merchandise in addition to daylight is preferred here. This also involves using pinpoint accent lighting to emphasise perceived contrasts. In the evening and when there is little daylight, even low illuminance levels are sufficient to attract the curiosity of passers-by with wide-area, subtly changing ambient lighting.



(7) Eye-tracking studies carried out at Douglas and SPAR proved that the lower levels of shelves in particular go relatively unnoticed. Targeted accent lighting or dynamic lighting in the lower third of shelves results in customers lingering longer and may possibly boost sales. Basically, shelf-integrated lighting is recommended at all levels.



(8) The way that light is directed onto shelves is also crucial: wide-area backlighting of shelves produces a more attractive effect than accent lighting only. A combination of backlighting and accent lighting makes identification of merchandise easier and makes the presented goods look more attractive.

## 6 Discussion and outlook

The study demonstrated how subjective the factors of brightness, light distribution and light colour influence the attraction and purchasing behaviour of customers in a shop. The perception of test subjects in virtual surroundings with changing light conditions was also measured. It was shown in general how difficult it is to carry out such as survey of lighting effects with such individual, brand-related and emotional applications. Despite this difficulty it could be proved that it is not only the brightest point that attracts the glances of passers-by and thus influences perception, but that it is primarily a matter of contrasts in a shop window or shop. In practice the solution seems to be more practical, especially when it results in measures to reduce energy consumption. Alternative measures and suggestions were developed as a part of the study. In a next step, the fundamentals defined have to be tested in the real application with more test subjects and under controlled and comparable light situations. The combination or correlations between the individual parameters so far examined should also be analysed. Dynamic lighting solutions offer the advantage of individually adapting the lighting situation to specific situations.

Royal Institute of Technology in Stockholm/SE (KTH)

Prof. Jan Ejhed is the head of the lighting laboratory at the Royal Institute of Technology (KTH) in Stockholm/SE. He is also head of Division 3 at CIE, professor at the School of Design of the Linnaeus University and runs his own company. He brought in the student Xu Haoming to assist him in his research.

HAW Hamburg (Prof. Dr. Roland Greule)

Since 1996, Prof. Dr. Roland Greule has been professor of lighting technology at the University of Applied Sciences, as well as vice dean of the Design, Media and Information (DMI) faculty.

Felsch Lighting Design (Markus Felsch)

Markus Felsch studied lighting design at the HAWK Hildesheim. He has run his own company since 2004, and mainly devotes himself to perception-based lighting concepts for retail areas.



# ZUMTOBEL

## **Germany**

Zumtobel Licht GmbH  
Grevenmarschstraße 74–78  
32657 Lemgo  
T +49/(0)5261 212-0  
F +49/(0)5261 212-9000  
info@zumtobel.de  
www.zumtobel.de

## **Austria**

Zumtobel Licht GmbH  
Donau-City-Straße 1  
1220 Wien  
T +43/(0)1/258 26 01-0  
F +43/(0)1/258 26 01-82845  
info@zumtobel.at  
www.zumtobel.at

## **Switzerland**

Zumtobel Licht AG  
Thurgauerstrasse 39  
8050 Zürich  
T +41/(0)44/305 35 35  
F +41/(0)44/305 35 36  
info@zumtobel.ch  
www.zumtobel.ch

## **Headquarter**

Zumtobel Lighting GmbH  
Schweizer Straße 30  
Postfach 72  
6851 Dornbirn, AUSTRIA  
T +43/(0)5572/390-0  
F +43/(0)5572/22 826  
info@zumtobel.info