MASTER

Judging a book by its lighting
the effect of dynamic retail lighting on store revenue

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Judging a Book by its Lighting:

The Effect of Dynamic Retail Lighting on Store Revenue

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Abstract

With the increase in availability and popularity of online shopping, physical retail stores are finding it difficult to compete (Rigby, 2011). The stores often only have short moments of contact with customers (Bitner, 1992; Inman, Winer, & Ferraro, 2009; Mari & Poggesi, 2013). They are dependent on features of store atmosphere to entice customers into remaining in the store for a longer period of time and to make purchases. Therefore, the value of the store atmosphere features such as lighting, including dynamic lighting have increased. This study examined the effect of dynamic retail lighting on store revenue.

In the study, a quantitative field experiment is conducted, in which the lighting within a store was altered to measure its effect on total store revenue, English book revenue and Dutch book revenue. The experiment follows a 3 (color temperature: warm, cold, and warm-cold) x 2 (Light Transition: On-Number and Together) structure.

The results indicate that when compared with warm dynamic lighting, cold dynamic lighting has a significant positive effect on total store revenue and English book revenue. This is not the case for Dutch book revenue. The type of light transition has no significant effect on store revenue. The study concludes that (cold) dynamic lighting in a retail store has a significant positive effect on store revenue. However, this positive effect does not apply to all product categories. The implications of these findings include that stores should consider applying cold dynamic lighting, however differences between product categories should be kept in mind.

Key Terms: Dynamic Lighting, Retail Lighting, Store Revenue, Color Temperature

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Abbreviations

CCT	Correlated Color Temperature
CRI	Color Rendering Index
K	Kelvin
LMM	Linear Mixed Models
LSD	Least Significant Difference

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1 Introduction

This chapter provides insight into the company and the selected problem, the problem statement and research questions are also introduced, followed by the academic and practical relevance.

1.1 Empirical Context

This research took place at a small start-up company that produces dynamic lighting, called Invisua Lighting BV (henceforth referred to as Invisua). The company states that it is a light creator and aims to push the limits of professional lighting. The company specializes in three main groups, i.e. hospitality, retail, and showroom. The company is located near Eindhoven, the heart of the high-tech region in the Netherlands, and it works with dealers and customers in multiple countries.

The products Invisua offers its customers are dynamic led lighting solutions with an app to control the lights. Dynamic lighting refers to the changing abilities of light such as color, hue, and brightness. The company aims to bring the magic of dynamic natural light indoors. The associated dream is to have customers experience the same emotions from artificial light as from natural light.

To gain more practical insight into the problem at the company, an informal interview was held with the CEO of Invisua. This interview provides more insight into the company's customer base and the reasons for investing in dynamic lighting. One customer, a bookseller, believes that improving small features, such as lighting within a retail store, can (positively) influence its customer's behavior and in turn the store's revenue. This belief led to the creation of the experiment central to this study.

1.2 Problem Definition

With the increase in availability and popularity of online shopping, physical retail stores are finding it difficult to compete (Rigby, 2011). It is predicted that online sales will grow further in most product categories (de Hernandex & Hoogenberg, 2017; Pauwels & Neslin, 2015). This increase in competition led retail stores to re-evaluate how their products are offered to the customer. Some re-evaluations include a focus on quality over quantity, online presence, and product presentation (de Hernandex & Hoogenberg, 2017). A benefit of physical retail stores for customers is the physical connection to the product, service, and after-sales support (Pauwels & Neslin, 2015). Businesses benefit through increased contact with the customer and an increase in customer retention (Pauwels & Neslin, 2015)**.** Additionally, customers have a different decision making process when making purchases in a physical store when compared to online purchases (Pauwels & Neslin, 2015). There still remains significant value to brick and mortar stores, however it is important to maintain customer satisfaction. This can be done through product presentation (Gómez, McLaughlin, & Wittink, 2004). To increase the values of customer retention and satisfaction within a store, it is of interest for the store to present the products in the most enticing way and improve store atmosphere (Gómez et al., 2004).

Presentation of products includes factors such as cleanliness, music, signage, and lighting (Reddy, Reddy, & Azeem, 2011; Tantanatewin & Inkarojrit, 2016). For example, the placement of products at points where they are featured influences the purchase rate of the products (Hui, Huang, Suher, & Jeffrey Inman, 2013; Liu, Dallas, Harding, & Fitzsimons, 2018). Also, the friendliness and helpfulness of store employees can positively influence store revenue such that if the interaction between a store employee and customer is positive, the customer is more likely to purchase an item (Bitner, 1992). The cleanliness of a store can impact the store revenue, if a store is messy or dirty in appearance, fewer purchases will be made (Nordfält, 2011; Reynolds-McIlnay, Morrin, & Nordfält, 2017). Nordfält (2011) and Reynolds-McIlnay et al. (2017) state that products that are neatly presented will appear to have a higher price tag compared to products that are presented in a messy display. Also, customers are more likely to approach and interact with neatly organized products (Reynolds-McIlnay et al., 2017).

Multiple studies have researched the effect of store lighting colors and intensity on customer purchasing behavior and revenue (Barli, Aktan, Bilgili, & Dane, 2012; Tantanatewin & Inkarojrit, 2016). Outcomes of such studies indicate that lighting does indeed have an effect on purchasing behavior. For example, the color green stimulates customers to remain in the store for a longer period of time and increase their product purchases (Barli et al., 2012). As technology changes and increases over time, research has to be conducted on these new forms of technology. Within current literature, there are plenty of articles that research the effect of light on customer purchase intentions (Park & Farr, 2007a; Reddy et al., 2011). However, the literature that does examine the effect of lighting on customer behavior is most commonly conducted within a controlled lab environment and not in a physical retail setting (Reddy et al., 2011; Summers & Hebert, 2001). Also, there is little research that examines newer technology such as dynamic lighting. The articles that have studied the effect of dynamic lighting on human behavior often apply it within an office environment (de Kort & Smolders, 2010) and not a retail setting.

Retail stores often have short moments of contact with customers (Bitner, 1992; Inman et al., 2009; Mari & Poggesi, 2013). They are dependent on features of store atmosphere to entice customers into remaining in the store for a longer period of time and to make purchases. This increases the value of the store atmosphere features such as lighting, including dynamic lighting. With the limited amount of literature on dynamic lighting, there appears to be a valuable literature gap which this study aims to address. Therefore, the academic relevance of this research includes the study of the effect of dynamic lighting on store revenue in a retail setting.

Since dynamic lighting technology is a new opportunity for the company and its customers, the term opportunity statement is more appropriate than problem statement:

By investing in and applying dynamic lighting, a retail store might expect a change in its customer behavior and store revenue.

1.3 Research Questions

This paper aims to answer the following main research question:

What is the impact of applying dynamic lighting in a retail store on store revenue?

The following sub-questions are formulated with the aim to answer the main research question:

1. What is dynamic Lighting?
2. What is the relationship between light color temperature and store revenue?
3. What is the relationship between dynamic lighting and store revenue?
4. What is the relationship between changing light features and store revenue?
5. How can retail managers and lighting companies use the conclusions of this research within their businesses?

1.4 Research Approach

This research intends to generate knowledge about the effect of dynamic lighting on customer behavior in retail stores**.** In order to gain some control in the research process, a theoretical study according to van Aken, Berends, and van der Bij, (2012) is applied. There are two common research structures, i.e. the regulative cycle and the empirical cycle (van Aken et al., 2012). The regulative cycle is often applied to solve a specific business performance problem whereas the empirical cycle is used when the aim is to generate knowledge (van Aken et al., 2012). As stated earlier, this research will generate knowledge about dynamic lighting and store revenue, this would suggest that the empirical cycle is most appropriate for this study.

The empirical cycle consists of five steps, i.e. observation, induction, deduction, testing, and evaluation (van Aken et al., 2012). This model is presented in Figure 1. This research started with observations of the business phenomenon and opportunity within the real world setting as well as through literature (Chapter 1). The literature addresses the effect of basic light features on customer behavior, however, there is little literature that examines dynamic lighting and customer behavior. This indicates a gap in the literature as well as the value of this research. The second stage in the empirical cycle is induction. In this stage, the literature will be further examined and possible explanations for the phenomenon of dynamic lighting on customer behavior will be identified (Chapter 2). The theory is examined in two main streams, i.e. (dynamic) light features (such as color and brightness) and store revenue. Within the third step, deduction, the discoveries in the induction phase will be transformed into hypotheses (Chapter 2). For example, the first hypothesis is "*Cold blueish lighting (4,000K – 6,550K) has a positive effect on store revenue*". The fourth step is testing, here the developed hypotheses will be tested (Chapter 3). In this research, the testing is completed through an experiment at a bookshop. In this experiment, multiple lighting solutions have been installed in a select number of store locations. The experiment included applying various lighting scenarios for a limited amount of time. The intention of the experiment was to determine the effect of light on the sales of various product categories as well as store revenue. The fifth and final stage is evaluation (Chapters 4 and 5). The test output is examined and interpreted. In this stage the research question is answered, and a suggestion is made for retail managers and the implementation of dynamic light.

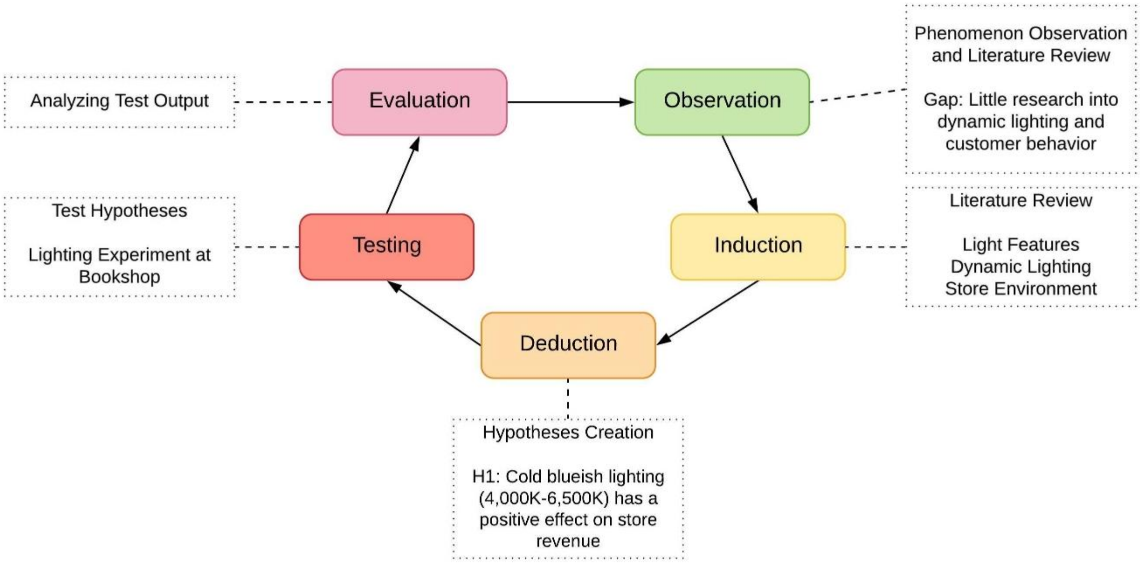

Figure 1- Empirical Research Cycle (van Aken et al., 2012)

1.5 Relevance

1.5.1 Academic Relevance

As technology changes and increases over time, research has to be conducted on these new forms of technology. Within current literature, there are plenty of journals that research the effect of light on customer purchase intentions (Park & Farr, 2007a; Reddy et al., 2011). However, the literature that does examine the effect of lighting on customer behavior is most commonly conducted within a controlled environment and not in a physical retail setting (Reddy et al., 2011; Summers & Hebert, 2001). Also, there is little research that examines newer technology such as dynamic lighting. The articles that have studied the effect of dynamic lighting on human behavior often apply it within an office environment (de Kort & Smolders, 2010) and not a retail setting. This presents a gap in the literature which this thesis study aims to address. Therefore, the academic relevance of this research includes the study of the effect of dynamic lighting on store revenue in a physical retail setting.

1.5.2 Practical Relevance

The goal of this research is to examine the relationship between dynamic lighting and a customer's buying behavior, which in turn affects a store's revenue. This research contributes to the identification and value definition of light to a retail store's revenue. For Invisua, this experiment is important to determine the most successful lighting combination, such that it can identify the value of dynamic lighting within a retail setting. Invisua can then apply this knowledge when approaching possible new customers and increase their own product sales. This knowledge might also be applicable in the retail industry as a whole. However, it might be dependent on the type of retailer. Future research would have to examine whether this is the case.

1.6 Research Scope

This study is structured around an experiment that has already been conducted before. This impacts the scope of the study. The original experiment has taken place in the Netherlands and will continue to take place in the Netherlands. Also, the original experiment applied light fixtures within the store. The light fixtures have predetermined properties and arrangements. Certain light features that are discovered in literature can therefore not be examined due to the predetermined properties. Some out of scope features include uniformity, contrast lighting, or glare and sparkle (Reynolds-McIlnay et al., 2017).

1.7 Thesis Structure

This thesis is structured in the following way. Chapter 2 presents the literature review which provides information concerning the various features of light and the relationship to customer behavior. A conceptual model and proposed hypotheses are also discussed in Chapter 2. The following section, Chapter 3, describes the methodology of the research. Chapter 4 presents the results of the various tests conducted. Finally, Chapter 5 examines the discussion of results and conclusions. Also included in this chapter are managerial implications, limitations of the study, and suggestions for future research.

2 Literature Background

This chapter describes the search strategy applied and the theoretical perspective of the research study. Literature on light features are discussed, hypotheses are formulated, and a conceptual framework is introduced.

2.1 Search Strategy

This literature research was completed through the examination of journals, books, and articles found via the search engines Google Scholar, Science Direct, and the Eindhoven University of Technology library. Based on the research question stated in Chapter 1, three literature streams can be suggested, dynamic lighting, retail lighting, and store revenue. Based on these literature streams certain keywords were determined. Because not every paper applies identical key terms for the same concept, it was decided to expand the range of possible studies to include synonyms of the selected terms. For example, for the term ‘store revenue’, another study might apply the term ‘retail revenue’. Table 1 presents a list of the first applied search terms and the associated synonym variations. By expanding the key terms to include variations, researcher bias is decreased and the electronic databases are searched more thoroughly (van Aken et al., 2012).

Table 1- Search Terms and Criteria

Search Terms and Variations

	Search Terms	Variations
First Applied Terms	Dynamic Lighting	Dynamic Light Installation
	Retail Lighting	Store Lighting, Retail Light Installations
	Store Revenue	Retail Revenue
	Store Environment	Store Atmosphere, Retail Environment, Retail Atmosphere
Additional Terms	Light Color	Light Color Temperature
	Lighting Features	Lighting Characteristics, Lighting Attributes
	Speed	Frequency
	Stroboscopic Effect(s)	Light Modulation, Flicker

The first searches include using the search terms “dynamic lighting”, “retail lighting”, “store revenue”, and “store environment” (see Table 1). In this first search, articles were only considered if they are written in English or Dutch and are digitally available. The articles also had to have a focus on management in the fields of business, retailing, atmospherics, marketing, entertainment, and lighting. Articles focused on the specifics of the technology were excluded. The next step includes examining the abstracts of each article. A selection of relevant articles was made based on answering the following question: does this article analyze the effect of (dynamic) lighting on human (customer) behavior or (store) revenue? If the answer is no, the article is excluded from this study. According to Randolph (2009), searches in electronic databases often lead to only about ten percent of all available sources. An effective method to discover the remaining 90% includes reading the references of the first articles and searching for the new articles. These steps should be repeated until saturation is achieved (Randolph, 2009). This process is also known as the 'snowball' method (van Aken et al., 2012). The application of both methods has led to a selection of 91 articles. With such a selection techniques, it is often advised to conduct this step with more than one reviewer (Randolph, 2009; Tranfield, Denyer, & Smart, 2003). However, this study is small, and it was not possible to add another reviewer. The final step includes reading the 91 articles and making a final selection. This selection is based on insight provided to answering the research question: *What is the impact of applying dynamic lighting in a retail store on store revenue?* The final selection of articles includes 45 articles. In Appendix I: Literature Background Method, a figure of the method applied can be seen (see Figure 8) and a table with the associated criteria (see Table 19).

2.2 Literature Matrix

Based on the discovered literature discussed below, a matrix is created to depict the gap in the literature (see Table 2). The matrix has the environment (retail and office) on the horizontal axis and lighting (dynamic and non-dynamic) on the vertical axis. Each quadrant in the matrix represents the literature that matches two of the literature streams. As can be seen, three of the four quadrants present a selection of available literature, with the exception of quadrant one. As stated in Chapter 1, there is no literature that examines dynamic lighting in a retail environment. This thesis aims to fill the gap and provide insight into dynamic lighting in a retail environment.

Table 2- Literature Gap Matrix

Literature Gap Matrix

	Retail Environment	Office Environment
Dynamic Lighting	*This thesis*	de Kort & Smolders, 2010; Kompier, Smolders, & de Kort, 2020; Logadóttir & Christoffersen, 2009
Non-Dynamic Lighting	Babin et al., 2003; Bellizzi & Hite, 1992; Söker, 2009; Tantanatewin & Inkarojrit, 2016; Yildirim et al., 2007	Jenkins & Newborough, 2007; Linhart & Scartezzini, 2011; Mills, Tomkins, & Schlangen, 2007; Moore, Carter, & Slater, 2002; Soori & Vishwas, 2013

2.3 Store Environment and Sales Revenue

Sales revenue is the income gained by an organization from selling goods and services (Ross, 2019). The sale of goods and services are the direct way to influence sales revenue. However, there are indirect methods that influence store revenue. Some indirect methods include product selection and placement, music, and store layout (Mohan, Sivakumaran, & Sharma, 2012). These features belong to store atmosphere and environment. Store environment is a collection of factors that stimulate a customer's experience of a retail store (Bitner, 1992; Gómez et al., 2004; Mohan et al., 2012). The environment of a store is able to influence purchase quantity, how a customer enjoys the store, the time spent in the store, as well as amount of money spent by a customer (Mohan et al., 2012). Literature indicates that attributes or features of store atmosphere influence customer satisfaction which lead to higher sales performances (Gómez et al., 2004), reinforcing the indirect nature of store environment on store revenue.

As shown in Chapter 1, the factors that influence the store environment are well researched in literature. However, the features of lighting are less well documented especially with new technological developments such as dynamic lighting (de Kort & Smolders, 2010). Therefore, this study takes a closer look at the relationship between different light features and store revenue.

2.4 Light

The purposes of retail lighting include providing ambience, attraction of attention, and merchandise accentuation (Tantanatewin & Inkarojrit, 2016). Many studies have examined the effect of light on a retail setting, however not many studies have been conducted within an actual store setting (Park & Farr, 2007b; Summers & Hebert, 2001). There even are some studies that have been completed without physical light sources. For example, one research measured the effect through verbal descriptions of lighting settings within store environments (Babin et al., 2003). Another research used graphical representations such as pictures and computer renderings (Schielke & Leudesdorff, 2015). Although these studies add value to the lighting literature, they limit their findings to personal preferences and attitudes (Quartier, Vanrie, & Van Cleempoel, 2014). Some retail lighting studies do use physical light sources, however, they test the effect within a controlled environment in which customer behavior is less natural (Reddy et al., 2011; Summers & Hebert, 2001).

2.4.1 Light Features and Attributes

For retailers, installing lighting is not a simple decision. Retail lighting consists of multiple features and attributes that combine to create the most optimal lighting within a store. Lighting design features for retail include arrangement of lighting, brightness, uniformity, contrast, glare and sparkle, color temperature, and light source properties (see Table 3) (Custers, De Kort, Ijsselsteijn, & De Kruiff, 2010; Tantanatewin & Inkarojrit, 2016). Such features and attributes contribute to the perception of the store's atmosphere. For example, glare and sparkle influence the liveliness or stimulation of a store's atmosphere to the customer (Custers et al., 2010). Due to the limited amount of research on the topic, it is unclear whether one or multiple light features have a greater effect on store revenue than others.

Table 3- Light Feature Definitions

Definitions of Light Features		
Feature	Definition	Source
Color Temperature	Also known as correlated color temperature (CCT) is a scale of variations of light ranging from warm red to cold blue. "The classification of a color as reddish, yellowish, greenish, bluish or their intermediaries or as having no color"	(Choudhury, 2014; Custers et al., 2010; Society of Light and Lighting, 2009b, p. 43)
Brightness	"Attribute of a visual sensation according to which an area appears to emit more or less light."	(Fairchild, 2005, p. 86; Tantanatewin & Inkarojrit, 2016)
Contrast	"The luminance contrast of a target quantifies its visibility relative to its immediate background. The higher is the luminance contrast, the easier it is to detect the target"	(Custers et al., 2010; Society of Light and Lighting, 2009b, p. 26; Tantanatewin & Inkarojrit, 2016)
Uniformity	An equal and consistent distribution of illumination across a room. Measured in the form of a ratio from most illuminated to least illuminated area in a room.	(Custers et al., 2010; Society of Light and Lighting, 2009b, p. 37; Tantanatewin & Inkarojrit, 2016)
Arrangement of Fixtures	The composition of various light sources such as overhead lighting, accent lighting, or display lighting.	(Society of Light and Lighting, 2009a, p. 182; Tantanatewin & Inkarojrit, 2016)
Glare and Sparkle	Glare is the discomfort in the visual field caused by high (above average) luminance. There are five forms of glare i.e. saturation, adaptation, disability, discomfort and overhead.	(Custers et al., 2010; Society of Light and Lighting, 2009b, p. 39)
Light Source Properties	Features relevant to specific lighting fixtures. Some properties include luminous flux, power demand, luminous efficacy, lumen maintenance, life, and color properties.	(Society of Light and Lighting, 2009c, pp. 77, 78; Tantanatewin & Inkarojrit, 2016)

2.4.2 Light Brightness

Brightness is defined as an "attribute of a visual sensation according to which an area appears to emit more or less light" (Fairchild, 2005, p. 86). The brightness of a single colored object (e.g. red) can have multiple forms of brightness (Reynolds-McIlnay et al., 2017). For example, the color hue 'light red', can be perceived to be brighter than dark red. Brightness also varies across color hues (Reynolds-McIlnay et al., 2017). A yellow object can appear brighter than a brown object. On the color hue scale, white is considered to be the brightest color, and black is the least bright color. Reynolds-McIlnay et al. (2017) also state that the brightness of an item is based on a subjective perception.

Within retail, it is common to see homogeneous lighting settings (Ampenberger, Staggl, & Pohl, 2017). Homogeneous lighting refers to a uniform lighting scene within a store and no highlighting of particular products or areas. This implies that there is no difference in light brightness within a store. However, Ampenberger et al. (2017) suggest that applying lights to highlight products and areas can be a natural solution for stores as it can attract a customer's attention to the selected area and product(s). Research has also indicated that high light brightness within a retail setting can lead customers to examine more products and stimulate a purchase (Reynolds-McIlnay et al., 2017; Schielke & Leudesdorff, 2015).

The brightness of lighting within a store also has the ability to highlight the state of product presentation (Reynolds-McIlnay et al., 2017). Products that were neatly displayed and highlighted with bright lighting were more likely to be approached. However, the products that had a messy display with bright lighting would be less likely to be approached, so much that a 35% decrease in sales was noted (Reynolds-McIlnay et al., 2017). This shows that light brightness that highlights the state of product displays can affect customer approach and purchase behavior, resulting in changes in store revenue. Therefore, if a retailer were to apply bright lights as a highlighting technique, it would be advised to maintain a neat display of products to avoid decreases in sales.

2.4.3 Dynamic Lights

The definition of dynamic lighting varies slightly per literary source. For example, de Kort and Smolders (2010) define dynamic lighting as an innovative lighting solution that applies lighting characteristics to biological and physical processes of the body, whereas Logadóttir and Christoffersen (2009, p. 169) state that "the dynamic lighting concept includes changes in light level and correlated color temperature (CCT)." The definitions head into a similar direction, however they both refer to biological processes which are not relevant to this study because store customers do not spend a large amount of time in a store. Therefore, dynamic lighting is defined as "the process of changing artificial light to mimic natural light and using these changes to influence (customer) behavior."

Natural light changes throughout the day, from a red rising sun in the morning to a dark and cloudy afternoon. In contrast, artificial lighting is usually constant in brightness as well as color (de Kort & Smolders, 2010). Dynamic lighting is the process of changing light features such as brightness and color temperature of artificial light to mimic and support the effect of natural light on a person.

Dynamic lighting studies are scarce for both lab and field research (de Kort & Smolders, 2010). The few studies that have researched dynamic lighting have been conducted within an office environment. In a study by de Kort and Smolders (2010), a dynamic lighting situation was tested on office workers. Their lighting simulation intended to stimulate the workers during the day with moments of relaxation during the breaks (see Figure 2). The dynamic light simulation applied changes in color temperature ranging from 3000K to 4700K to stimulate the workers. This suggests that dynamic lighting is not a light feature on its own but that it consists of altering the known light features to create the effect of dynamic lighting.

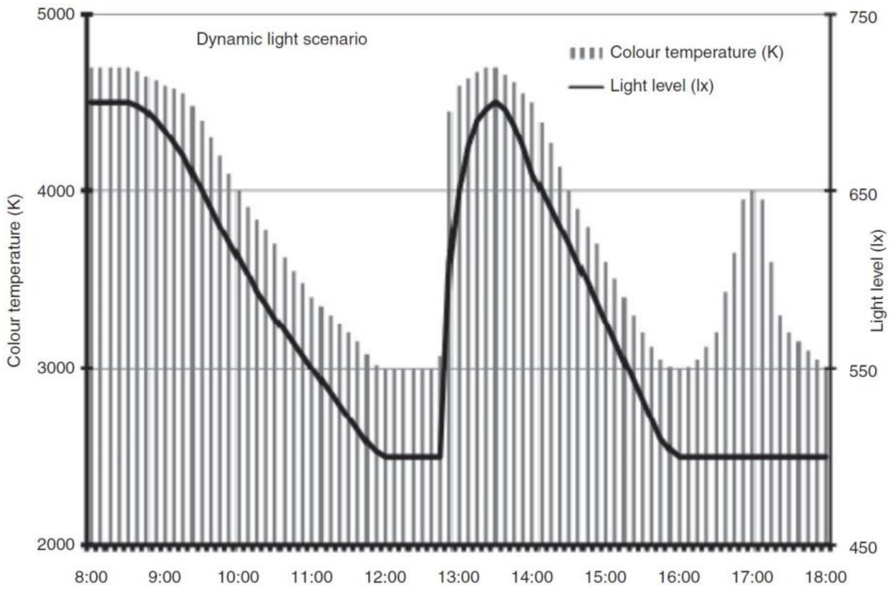

Figure 2- Dynamic Lighting Scenario at an Office: Brightness and CCT of Lighting Plotted Against Time of Day (de Kort & Smolders, 2010)

The study was unable to conclude that dynamic lighting has significant beneficial health effects in an office environment. However, the authors did note that the respondents were more satisfied working in a dynamic lighting environment than standard lighting (de Kort & Smolders, 2010).

2.4.4 Light Color and Temperature

Research has suggested colored light can influence a store's perceived image as well as its pricing strategy (Reddy et al., 2011).

2.4.4.1 Color

There are two groups of color; warm hues (red, yellow, and orange) and cool hues (green, blue, and purple) (Tantanatewin & Inkarojrit, 2016). Various research papers have investigated the effect of color hues on customer perception, experience, and emotions (Babin et al., 2003). For example, in a restaurant or café setting, a purple environment was more pleasantly perceived by the customer than a yellow environment (Yildirim et al., 2007). Another research within a restaurant setting suggests that warm color tones are pleasant, and customers perceive the prices to be lower compared to cool color tones (Söker, 2009). Cooler colors lead to a sense of reliability and positive images as opposed to warmer colors which create longer shopping experiences and excitement (Bellizzi & Hite, 1992).

A color's gradation or hue is defined by its wavelength (Babin et al., 2003). Cooler colors tend to have shorter wavelengths, where violet has the shortest wavelength. Warm colors have long wavelengths and red has the longest wavelength (Babin et al., 2003). Babin et al. (2003) state that cooler colors with short wavelengths are preferred over warmer colors with long wavelengths. Within a simulated retail setting, Babin et al. (2003) discovered that a store with blue displays produce higher purchase rates compared to a red display. Also, purchase intentions were higher in a blue treatment environment than in a red treatment environment. Therefore, it is suggested that colder colors, such as blue, have a positive effect on store revenue.

2.4.4.2 Color Temperature

Color temperature of light also known as correlated color temperature (CCT), is a scale of variations of light ranging from warm red to cold blue (Choudhury, 2014). This scale is measured in degrees of Kelvins (K). Low degrees of kelvin are warmer colors and high values of Kelvin represent colder colors (see Figure 3). A match or candle emits warm red light and is equal to around 1,700K - 1,800K and overcast daylight is approximately equal to 6,500K which is cold blue light. This scale is also applied to light fixtures and light bulbs. A warm white light bulb will emit light in the 2,700K to 3,000K range.

The Kelvin scale will also be applied in this study as it is the standardized method of measurement of light color temperature.

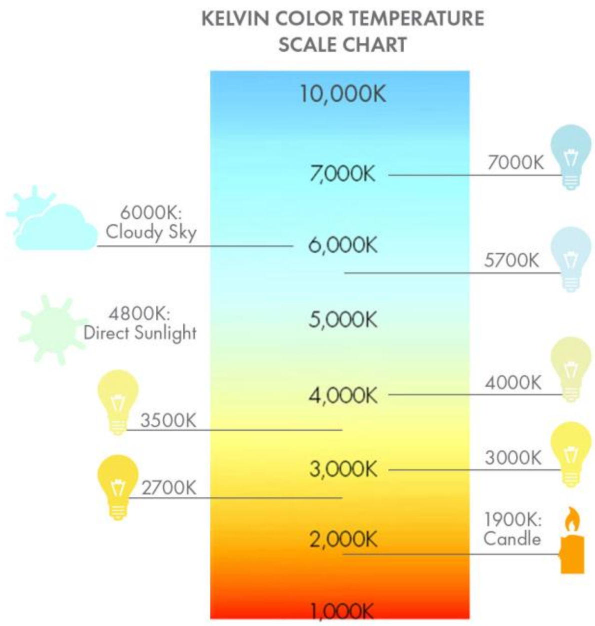

Figure 3- Kelvin Color Temperature Scale Chart (Pacificolux Lighting, 2019)

Considering how cooler colors stimulate a sense of reliability and lead to higher purchase intentions and purchase rates (Babin et al., 2003; Bellizzi & Hite, 1992), cooler colors (vis-à-vis warm colors) will be expected to have a positive effect on store revenue than warm colors. Using the CCT scale, the cooler colors fall into the 4000K to 10,000K end of the scale. Warmer color lighting would range from 1,000K to 3,500K. Therefore, the following hypotheses are proposed:

H1: Cold blueish lighting (4,000K – 10,000K) has a positive effect on store revenue.

H2: Cold blueish lighting (4,000K – 10,000K) will have a greater positive effect on store revenue than warm red lighting (1,000K – 3,500K).

2.4.5 Color Rendering Index (CRI)

Color rendering is one of the properties of a light source and refers to how natural an object's colors appear when placed under a light source (Davis & Ohno, 2005; Ohno, 2005). The color rendering index (CRI) is the international metric that assesses the performance of color rendering (Davis & Ohno, 2005; Ohno, 2005). The assessment of color rendering performance is completed by examining color differences of 14 samples when placed under the tested light source and under a reference light source. For the reference light, daylight and incandescent light are applied. The 14 samples consist of eight medium-saturated colors and the final six are highly saturated colors, such as red, yellow, and blue. Once the values in color differences are known, they will be applied in a calculation to discover the *Special Color Rendering Indices* (Davis & Ohno, 2005; Ohno, 2005). A perfect color rendering can have a score of 100 and implies that the light source perfectly presents the color of an object under its light. A poor color rendering score (below 80) indicates that the light source is not applicable for lighting in a general setting (U.S. Energy Policy Act of 1992) (Ohno, 2005). It is also mentioned that CRI is often mistaken to also measure the hue discrimination or subjective impressions of color, however, this is not what CRI measures.

The CRI is relevant to stores because it can influence the appearance of a product in a store compared to at home or outside (Freyssinier & Rea, 2010). However, as technology progresses so does new technological developments in light. In particular the development of the LED light has caused challenges for the CRI metric (Davis & Ohno, 2005; Freyssinier & Rea, 2010). As stated earlier, the CRI metric is associated with hue discrimination, which it does not measure. Some researchers have attempted to develop a new metric that would expand CRI to include hue distinctions (Davis & Ohno, 2005; Freyssinier & Rea, 2010; Ohno, 2005). Another challenge of CRI is that it applies natural daylight as a reference light, however this also leads to a color preference. Natural daylight falls into the 5000K to 6500K range on the CCT scale. According to Ohno (2005), manufacturers of fluorescent lamps design their products to meet the preferences of their target market. For example, in the USA, 6500K white light will not be tolerated in the home, while in homes in Japan 5000K is preferred (Ohno, 2005). This indicates that "natural daylight" often has a personal preference and cannot be applied to all markets. When combining this literature with color temperature findings, it can be suggested that CRI has an influence on the perception of individual color temperatures, which can decrease the effectiveness of color temperature on sales revenue.

2.4.6 Changing Light Features and Attention Capturing

Retail stores often try to direct a customer's attention to specific objects for sale. Some methods include the cleanliness of the display or placing televisions near the displays (Nordfält, 2011; Reynolds-McIlnay et al., 2017). One study found a positive effect between capturing a customer's attention through changing digital displays and the increase in purchases from the display (Nordfält, 2011). Considering how the effect of changing digital displays has a positive influence on customer purchase behavior, it is suggested that changing light features such as color and brightness can attract a customer's attention and increase the purchase ratio. This will lead to an increase in store revenue. The following hypothesis is proposed:

H3: Transitioning light features have a positive effect on store revenue.

An additional hypothesis is proposed combining the color temperature and the transition literature.

H4: The combination of cold blueish lighting and light transition has a positive effect on store revenue.

2.4.7 Frequency of Change

A stated in Section 2.4.6, changes in light is suggested to attract a customer's attention toward a highlighted product or area. It is important to discover what frequency of lighting change have an impact on customer behavior and which frequencies do not.

In literature, the terms 'stroboscopic effects', 'light modulation' and 'flicker' are used to describe changes in lighting (Olsen, Spaulding, Davey, & Ring, 2014). There is a limited amount of literature that examines light modulation effects (Olsen et al., 2014). The literature that has researched light modulation often have done so with lighting that is expected to remain constant (solid state lighting). From the discovered literature the following conclusions are stated. The detection of a flicker is linked to the modulation frequency (Veitch & Mccoll, 1995) and lower frequencies are easier to notice. Studies have defined low frequencies to be around 50Hz and high frequency to be 100kHz (Johansson & Johansson, 2003; Veitch & Mccoll, 1995). Research also indicates that lower frequency modulations cause more visual fatigue to users (Johansson & Johansson, 2003; Veitch & Mccoll, 1995). It is difficult to apply these findings to dynamic lighting because of its non-constant nature. Dynamic light is expected to change over time (i.e. be dynamic). What can be taken from these findings is that it is best to apply changes at higher frequencies to avoid negative effects such as visual fatigue. However, this also depends on the environment of the research and how long the 'users' are expected to remain within the light.

One article did examine the effect of changing light features on eye movements within a retail environment (Laski, Brunault, Schmidt, & Ryu, 2020). However, the study did not define a method for determining the frequency of change. The researchers defined a value for frequency of change based on their own visual evaluations. This value was a change occurring every 12 seconds (Laski et al., 2020). Aside from this study, no other articles have been found that examine whether a difference in frequency of change (in lighting) has an effect on customer behavior or store revenue.

2.5 Location

As stated in Chapter 1, retailers are dependent on the short amount of time that customers spend in the store (Bitner, 1992; Inman et al., 2009; Mari & Poggesi, 2013). This ‘time pressure’ is even more salient for customers that travel and commute. Locations such as train-, metro-, bus-, subway-stations and airports will encounter more travelling customers than other locations such as the high-street. Therefore, the effect of location is also discussed in this study.

The location of a retailer has an influence on customer experience and purchase behavior (Lin & Chen, 2013; Tinessa, Pagliara, Biggiero, & Delli Veneri, 2020; Turhan, Akalın, & Zehir, 2013). For example, the airport retail environment has a unique effect on consumers. The airport retail environment stimulates feelings of anxiety, excitement, and stress due to the time pressure of departing flights (Lin & Chen, 2013). It is also suggested that customers experience a ‘happy hour’ moment where the stress of checking in and passing security is decreased and the excitement of traveling remains high (Lin & Chen, 2013; Omar & Kent, 2001). Such stimulations can cause differences in purchasing behavior such as impulsive buying compared to customers in a high street environment (Omar & Kent, 2001). Interestingly, the type of product also has influence on customer shopping behavior (Lin & Chen, 2013). Time spent by customers at an airport include closely and physically examining products and possibly deciding to purchase the product at another retail location. Products categories such as books and souvenirs less susceptible for this effect (Lin & Chen, 2013).

Another retail location where customers are in travel modus includes a train station. Train station retailing differs intrinsically from airport retailing (Gonzalez & Siadou-Martin, 2017). Visitors and customers at a train station do not solely consist of travelers such as at an airport but also include commuters to and from work. This is similar for metro-, bus-, and subway stations (Tinessa et al., 2020; Turhan et al., 2013). Gonzalez & Siadou-Martin (2017) also discover that train station retail customers are motivated by the process of buying and not the expected utility that comes from consuming their purchase. A train station consists of four contextual elements that influence the relationship between customer and location. The elements are time, location, lack of alternatives, and uncertain conditions (Gummerus & Pihlström, 2011). The literature suggests that the location has an indirect and moderating effect on the relationship between lighting and product sales.

2.6 Product Categories

Studies have indicated that products sold within a store can be of influence on the effect of light. For example, when studying the effect of light on customer approach-avoidance behavior, Summers and Hebert (2001, p. 149) suggest that “merchandise content, need, or lack of need to try on merchandise, and pricing methods may be important influence in concert with light levels”. This indicates that the type of product, its pricing method, as well as the need of the product can influence whether customers will approach a product.

As mentioned in Chapter 2.4.2, the display state of products (neat or messy) can greatly influence customer approach and purchase behavior when highlighted by bright lighting (Reynolds-McIlnay et al., 2017). The paper discovered a positive effect between neatly presented products with high brightness contrast and a reverse (negative) effect between messy products and high brightness contrast. The bright lighting highlighted the state of the product display, where a messy display could lead to a 35% decrease in sales.

The presentation of products is also linked to perceived product price (Nordfält, 2011)**.** The paper stated that a messy display can lead a customer to believe that the product is cheaper and be more likely to purchase the product. This suggests that products within a store should be neatly presented especially if they are highlighted with bright lighting.

A difference between product categories is also discovered. For example, one study found that different products influenced the approach behavior of customers (Quartier et al., 2014; Summers & Hebert, 2001). Customer approach behavior was higher for products that required handling and closer examination, i.e. belts, than for products that could be examined from a distance, i.e. tools (Summers & Hebert, 2001). This indicates that product categories influence customer behavior.

Based on the literature, it is suggested that product categories and product presentation have a moderating influence on the relationship between lighting and store revenue.

2.7 Conceptual Model

In this chapter the relationship between lighting and store revenue is examined. Based on the examination, a model of the literature (see Figure 4) as well as a conceptual model (see Figure 5) for the study were created. A conceptual model is a representation of the discovered literature and their relations to one-another (Elangovan & Rajendran, 2015). The literature model in this study intends to be a guide for future research studies concerning lighting and store revenue. The conceptual model is focal to this study and represents the relationships of the chosen literature and the proposed hypotheses.

Due to the focus of this literature study on light, two groups are created in the model. The first group represents features of store atmosphere such as product placement, employee friendliness, cleanliness, promotions, and external store environment. This group is colored in a lighter color because it is out of scope of this study. The other group includes the light characteristics in this study. Namely, dynamic lighting, color temperature, brightness, frequency of change and CRI. Literature indicates that these features have an indirect effect on the sales of products and services leading to changes in store revenue (Babin et al., 2003; Choudhury, 2014; de Kort & Smolders, 2010; Reddy et al., 2011; Reynolds-McIlnay et al., 2017). Two additional features are also discussed in this study. These include store location and product categories. Store location, for instance, affects buying behavior thus influencing product sales and store revenue (Gonzalez & Siadou-Martin, 2017; Gummerus & Pihlström, 2011; Lin & Chen, 2013;

Omar & Kent, 2001). Therefore, this feature is applied as a moderator in the relationship between light characteristics and store revenue. A moderator is a variable that influences the relationship between an independent variable and a dependent variable. The product categories variable is also applied as a moderator.

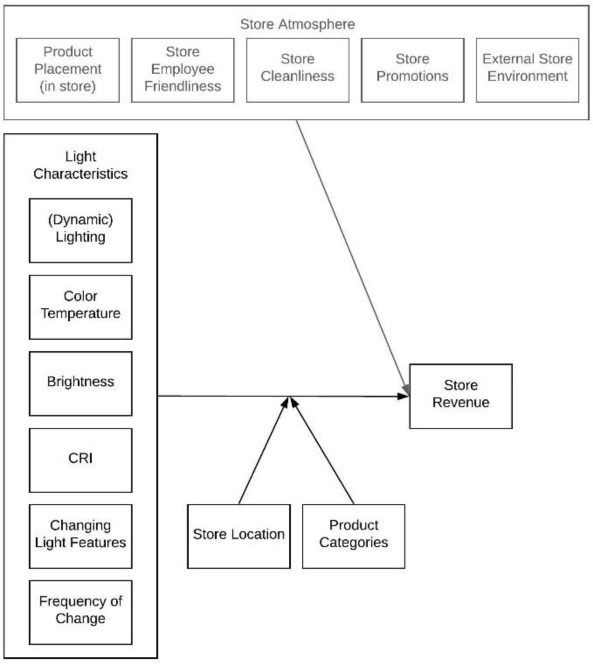

Figure 4- Model of the Literature

For this thesis, the following conceptual model (Figure 5) is created with the proposed hypotheses (H1, H2, H3, and H4). The applied variables are selected based on the limitations of the experimental design of this study and the value of lighting features towards sales revenue (see Chapter 3). The experimental design of this study limits the number of variables that can be tested (Koschate-Fischer & Schandelmeier, 2014). A selection of two is made to limit the complexity of the study (explained further in Chapter 3). Also, the experiment is dependent on the certain properties of the lighting fixtures itself as well as their placement within the store. This is because the light fixtures have been placed prior to the start of this study. This removes the following two light features as variables in this experiment, arrangement of fixtures, and light source properties.

Literature indicates that lighting color temperature affects customer behavior leading to higher purchase rates and store revenue (Babin et al., 2003; Bellizzi & Hite, 1992; Yildirim et al., 2007). Whereas other lighting characteristics such as brightness appear to have an effect on store revenue but the strength of the relationship is less direct as brightness stimulates customer approach and interaction behavior (Ampenberger et al., 2017; Schielke & Leudesdorff, 2015). Brightness is also strongly related to product presentation which is not examined in this study (Reynolds-McIlnay et al., 2017). Also, dynamic lighting requires the light features to change, making the lighting 'dynamic' and not 'static' (no change). The changes in lighting are defined as 'transitions' in this study (see Chapter 3). It is proposed that the changes in lighting can act as a method of attention capturing method within a store (Nordfält, 2011; Reynolds-McIlnay et al., 2017). Therefore, the transitions of lighting features are considered relevant for this study.

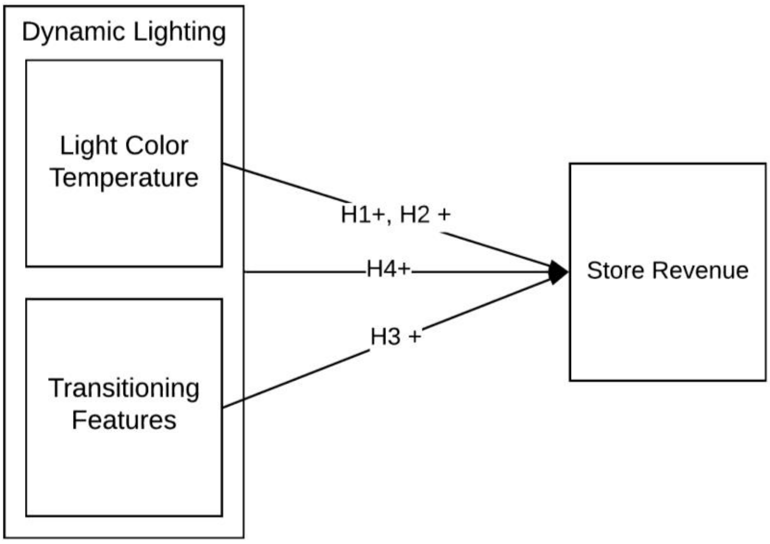

Figure 5- Conceptual Model with Hypotheses

3 Methodology

This chapter describes the research method applied in this study. The reason for an experimental design is described first. Next, the experiment and participants are defined, followed by the method of analysis. Finally, the research quality terms are stated.

3.1 Research Design

The hypotheses in this research are tested by means of conducting an experiment. An experiment was chosen because this study systematically manipulated variables and measured whether there was a change in store revenue, this is a common method for an experiment (’t Hart, Boeije, & Hox, 2009). There are two common types of experiments, lab-experiments and field-experiments (’t Hart et al., 2009; Koschate-Fischer & Schandelmeier, 2014). Each type of experiment has its own advantages and disadvantages. For example, in a lab experiment, external variables can be more easily be controlled, which positively influences the internal validity. However, due to the controlled nature of the set-up, the generalizability of the results are lower (’t Hart et al., 2009; Koschate-Fischer & Schandelmeier, 2014). A field experiment can increase generalization because the tests are conducted within a natural environment (Koschate-Fischer & Schandelmeier, 2014). A disadvantage of a field experiment is the lower internal validity due to lack of control of external variables. Table 4 shows the advantages and disadvantages of each type of experiment.

Table 4- Experiment Type Advantages and Disadvantages

Experiment Type Advantages and Disadvantages

Experiment Type	Advantages	Disadvantages
Laboratory	Control over external variables Higher internal validity	Lower generalizability
Field	High generalizability	No control over external variables Lower internal validity

(’t Hart et al., 2009; Koschate-Fischer & Schandelmeier, 2014)

Based on the advantages and disadvantages described above, it was decided to conduct a field-experiment. This was because a field experiment has a high generalizability. Also, the original experiment on which this experiment was based was a field experiment. The physical setup from the original experiment was still in place, allowing for significant shorter preparation time for the new experiment. This original experiment is described below.

Previous to this study, the company already had conducted an experiment at bookstores in high traffic areas with commuting and travelling customers. This was in the form of a field experiment because it took place in a natural environment. However, this original experiment was set up in a manner that lacked structure and academic support. The experiment was created with the idea of testing the effect of changes in light color and transition on store revenue. The variables were tested in a random manner where not all combinations of variables were examined. Because not all combinations were tested, it was not possible to examine whether one of the variables might have a greater effect on store revenue than the other. Also, length of each test lacked structure such that the tests varied from 1.5 weeks to four weeks. Due to the unstructured nature of the original experiment, it was decided to create a new experiment based-on academic literature and using a structured full-factorial approach. The same variables as in the original were examined. The factorial approach allowed for an examination of each combination of variables, which was missing from the previous experiment. Therefore, the four hypotheses are tested with the experiment. The setup of the experiment is described below.

3.2 Experimental Design

As described in Chapter 3.1, the new experiment was an extension of the original experiment but with more structure and academic support. Thus, the physical set up of the experiment within the stores remained the same as the previously conducted experiment.

For an experiment, it is common to have one or multiple independent variables based on research questions (Koschate-Fischer & Schandelmeier, 2014). It is suggested that two to three variables are preferred to limit the complexity of the experiment. An experiment that includes four or more variables will create an extremely complex project (Bortz & Döring, 2006; Koschate-Fischer & Schandelmeier, 2014). Once the independent variables have been defined, it is important to determine the levels per independent variable and how they are combined. The combinations of independent variable levels will result in a full-factorial design if all variables are included (Koschate-Fischer & Schandelmeier, 2014; Montgomery, 2013). To limit complexity of the experiment, it was decided to include only two variables, namely color temperature and light transition.

The experiment followed a 3 (color temperature: warm, cold, and warm-cold) x 2 (Light Transition: On-Number and Together) structure. This structure created six scenarios (see Table 5) to be tested. The experiment took place at eight bookstores throughout the Netherlands (see Table 7).

Each scenario alternated with the control scenario (A) throughout the week (see Table 6), such that on Monday test scenario B was applied and the control scenario A was run on Tuesday. The CEO of Invisua indicated in an informal interview, that this rotation intends to reduce the effect of external influencing factors such as seasonal trends, national holidays, and school vacations.

Table 5- 3x2 Experimental Design

Experimental Design (Color Temperature and Transition)

		Transition	
		On-Number	Together
Color Temperature	Warm-Cold	B	C
	Warm	D	E
	Cold	F	G

Table 6- Scenario Schedule (2 weeks)

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Week 1	Test Scenario	A	Test Scenario	A	Test Scenario	A	Test Scenario
Week 2	A	Test Scenario	A	Test Scenario	A	Test Scenario	A

Test Scenario:	B, C, D, E, F, G	A	Control Lighting

3.2.1 Participating Stores

Eight bookstores from the same company, an Invisua customer, participated in the experiment. Each store was fitted with at least 12 dynamic light fixtures. The stores were located at two high traffic areas where the customers often commute and travel. It was requested by the bookstore to mask the locations of the stores. Therefore, the specific locations cannot be stated. Table 7 presents the various stores and number of lights applied for this study.

Aside from defining the location of each store, the external environment lighting should also be considered around the store. Both Location 1 and Location 2 are inside venues where external lighting consists largely of artificial lighting. Each store is located at the center of their respective locations, limiting influences from natural outside light.

Table 7- Store Location and Setup

Store Locations and Setup

Store Name	Location	Number of Lights	Light Application
Store 1	Location 1	20	20 for five tables
Store 2	Location 1	12	12 for four tables
Store 3	Location 1	16	16 for four tables
Store 4	Location 1	16	16 for four tables
Store 5	Location 2	12	12 for three tables
Store 6	Location 2	16	16 for four tables
Store 7	Location 2	16	16 for four tables
Store 8	Location 2	16	16 for four tables

At Store 1, 20 lights were directed at the five tables, four lights per table. Store 2 contained 12 lights covering four tables, with three light fixtures per table. Store 3 and 4 applied 16 lights illuminating four tables with four lights per table. Stores 6, 7, and 8 had a similar layout of 16 light fixtures, whereas Store 5 applied only 12 lights for three tables, with four lights per table. Figure 6 depicts a generalized store layout. The locations Store 1, Store 2, and Store 5 differed slightly from this figure due to the varying number of light fixtures or tables.

On the tables, the bookstore placed selected product groups that were highlighted by the light fixtures. These product categories remained constant throughout the experiment. As described in the literature, product categories and their presentation can influence store revenue (Nordfält, 2011; Summers &

Hebert, 2001) especially when they are highlighted by store lighting (Reynolds-McIlnay et al., 2017). The selected product categories included English and Dutch books. Because these products were highlighted by the dynamic light installation, the specific product revenue data for the product groups (EN book and NL book) were applied in the analysis, alongside the total store revenue data.

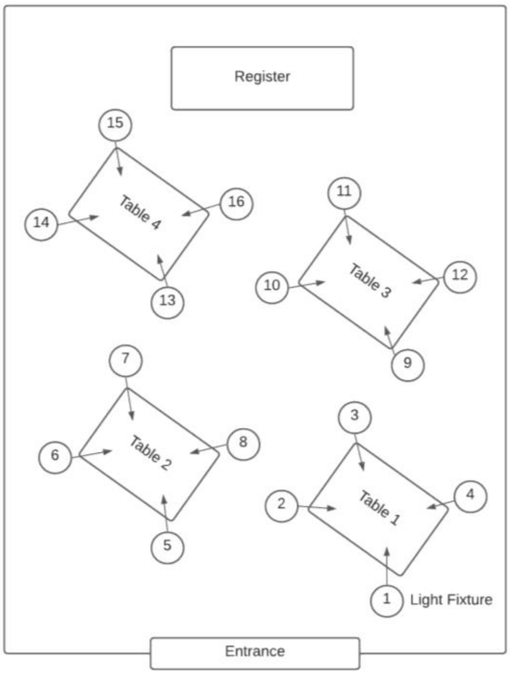

Figure 6- Generalized Store Layout

3.2.2 Scenarios

Table 8 presents the scenarios that were tested in the experiment. Each scenario was designed to test a combination of lighting features with the exception of Scenario A, which was the standard control setting for the store. The color temperatures were assigned specific Kelvin values from the CCT scale. This study defined the color temperature 'warm' within the range of 1,000K to 3,500K. The color temperature 'cold' was defined within the range from 4,000K to 10,000K on the CCT scale. The standard store lighting fell within the 'warm' range (Scenario A). It was requested by Invisua to mask the final selected temperature values due to confidentiality. Therefore, the selected values presented below and in Table 8 represent an altered version of the applied values.

The variable "transition" was operationalized in two levels: On-Number and Together. When the light fixtures were installed at a store location, each fixture was assigned a number (see Figure 6). The On-Number transition allowed the lights to change based on their assigned number. The light fixture number 1 changed its color first, next light fixture 2 changed and so on. To ensure that the light transition effect occurred per table instead of over the whole store, the lights were grouped per table. Four lights were assigned to a single table (with the exception of Store 2 with three lights per table). Therefore, lights one through four belonged to Table 1 and the scenario played over those four lights. The second level of transition was named Together. In this setting the grouped table lights changed from one color temperature to the other temperature together instead of individually. To avoid having one color temperature throughout the whole store, the lights were again grouped together per table and two out of four tables started with the second color temperature. This way, half of the store was lit in the first color, and the other half in the second color.

Following the 3x2 experimental design, each level of color temperature was matched with the two transitions. The first test scenario, i.e. scenario B, combined a warm-cold level variable with the 'On-Number' transition. The scenario intended to examine the effect of extreme color variations (2,000K and 9000K) with exciting changes in the lights. Note that this scenario was re-run after the planned experiment (16 November to 29 November) due to errors with the system. The data from the first run is replaced with the data from this repeated run. Scenario C applied the same color temperatures as B with the second transition 'Together'. Again, it tested the extreme color temperatures with a more easy-going change. The third test, scenario D, examined the effect of two warm colors temperatures (2,000K and 4000K) with 'On-Number' as the transition. Scenario E tested the two warm colors with the 'Together' transition setting. Scenario F tested the effect of cold lighting (4000K and 9000K) with the 'On-Number' transition. The sixth scenario, G, applied the cold color temperatures with the 'Together' transition.

Table 8- Experiment Scenarios

Experiment Scenarios

Scenario	Color Temperature	Color Temperature Values [a]	Transition
A	Standard Settings	4000K	Static (no change)
B	Warm – Cold	2000K, 9000K	On-Number
C	Warm – Cold	2000K, 9000K	Together
D	Warm	2000K, 4000K	On-Number
E	Warm	2000K, 4000K	Together
F	Cold	4000K, 9000K	On-Number
G	Cold	4000K, 9000K	Together

a. These values have been altered due to confidentiality.

3.2.3 Time

Table 9 presents a schedule of where and when each test was run over the course of the experiment. Two weeks were applied for each test. Each scenario started on Monday and ended on Sunday. As explained earlier, the tested scenario alternated each other day with the control Scenario A (Table 6). Therefore, both the tested scenario and the control scenario were applied once on every day of the week during the two weeks.

Table 9- Experiment Planning

Experiment Planning				
Scenario	Starting Date	Ending Date	Length of Test	Location
B	24-Aug-20	06-Sep-20	2 weeks	All locations
C	07-Sep-20	20-Sep-20	2 weeks	All locations
D	21-Sep-20	04-Oct-20	2 weeks	All locations
E	05-Oct-20	18-Oct-20	2 weeks	All locations
F	19-Oct-20	01-Nov-20	2 weeks	All locations
G	02-Nov-20	15-Nov-20	2 weeks	All locations
Repeat B	16-Nov-20	29-Nov-20	2 weeks	All locations

3.3 Method of Analysis

The data gathered in this study was collected over the course of 12 weeks from the same sample and the independent variables were changed every two weeks. This indicates that the data is repeated measures data (West, Welch, & Galecki, 2014). The (general) linear mixed model (LMM) is an analysis model suitable for clustered, longitudinal and repeated measures data which is applicable for the collected data in this study (West et al., 2014). LMM is able to quantify a relationship between dependent variables that are continuous and independent predictor variables that vary (West et al., 2014). The model is named ‘mixed’ because it combines fixed- and random-effect parameters. A fixed factor is a qualitative covariate where all conditions in an experiment are present for all subjects, such as the design variables of a study (Field, 2013; West et al., 2014). Random factors are classification variables where the levels are randomly sampled from the population of levels (Field, 2013; West et al., 2014).

The analysis method was applied twice to the data. Once, to measure the effect of the individual experimental variables ‘color temperature’ and ‘transition’. In this analysis the variables ‘color temperature’ and ‘transition’ were applied as fixed factors. The second application measured the combination of the experimental variables (‘color temperature’ and ‘transition’). Table 8 presents these combinations and each combination is labeled as a ‘scenario’. In this application the variable ‘scenario’ was taken as fixed. This study did not apply any random factors. The store names were applied as the subjects in the analysis to control for the individual stores. The location of the store (Location 1 and Location 2) and day of the week were controlled for through data transformation (normalization) which is described further in the Section 3.4.

During the analysis adjustments were made for multiple comparisons. It was decided to apply least significant difference (LSD) because it is less conservative than Bonferroni which is more common. Additionally, for the estimation method, the maximum likelihood method is applied instead of restricted maximum likelihood. To complete the LMM analysis, the software program IBM SPSS Statistics 25 will be applied. Appendix II: Syntax presents the applied SPSS Syntaxes.

3.4 Data Preparation

To allow for data analysis, categorical variables were coded to provide a numerical value. The independent variable of test scenario was coded into numerical values. Scenario A was given the value 0, B the value 1 and so on. The same coding was applied to the experimental variables 'color temperature' and 'transition'. The levels in the variables were coded such that the level 'Warm-Cold' was give the value 1, level 'Warm-Warm' value 2, and 'Cold-Cold' value 3. The level 'On-Number' was given value 1, and 'Together' value 2. Table 10 presents the complete list of the applied codes.

Table 10- Variable Coding Schemes

Variable Coding Schemes

Variable	Coding	
Scenario	A	0
	B	1
	C	2
	D	3
	E	4
	F	5
	G	6
Color Temperature	Warm- Cold	1
	Warm- Warm	2
	Cold- Cold	3
Transition	On-Number	1
	Together	2

Between the stores, the revenue values differed. For example, Store 7's daily revenue values greatly differed from the other Location 2 stores. This is most likely because it was located in a central area where more travelers pass through than the other area in Location 2 stores. There is also a difference between the Location 1 and 2. For example, the two types of customer can differ between stores, Location 1 saw more travelling customers than commuting customers, whereas Location 2 experienced both groups. The day of the week also had an effect on store revenue. For example, during the weekends a different customer group would visit a store compared to the commuters who visited during the work week. To compensate for these effects, the revenue data was normalized. This is completed through subtracting the control day from a test day. This was done for the same day in the week during one test. For example, in test B, the second Monday (control) was subtracted from the first Monday (test). By applying this calculation, the differences between store revenue as well as day of the week and location were reduced.

3.5 Research Quality

To ensure the quality of the research, it was tested on three factors; controllability, reliability, and validity (van Aken et al., 2012).

Controllability is required to test reliability and validity of a research. Controllability can be ensured through the creation of a clear methodology. This was achieved through the extended methodology in the research study. All steps of the research are documented. Reliability and validity describe the accuracy of research output (van Aken et al., 2012). Reliability is defined as "the extent to which a variable or set of variables is consistent in what it is intended to measure" (Hair, Babin, & Anderson, 2014, p. 91). Reliability was achieved through the repetition of each scenario throughout the two weeks and not only on a single day. Validity is how well a concept is measured by the selected variables (Hair et al., 2014; van Aken et al., 2012).

Within validity, there is internal and external validity. Both are affected by the experimental nature of the study. Internal validity refers to the conclusions about the relationships between phenomena (van Aken et al., 2012). It is suggested that a field experiment such as this study possess less internal validity due to the uncontrollable external factors (Koschate-Fischer & Schandelmeier, 2014). This study first examined the phenomena through literature before testing the phenomena in the experiment. This increases the internal validity and confirms that the selected variables are relevant to the study. External validity refers to the generalizability of the research to other firms and industries (van Aken et al., 2012). Field experiments are also believed to have greater external validity due to the 'naturalness' of the environment ('t Hart et al., 2009). Therefore, this study is believed to have produced results that can be easily applied to other companies with similar products.

4 Results

This chapter presents the results of the experiment. Section 4.1 describes the irregularities during the experiment that have affected the data collection process. Section 4.2 provides the descriptive statistics.[1] Section 4.3 shows the results and hypothesis testing. In the sections below the terms 'positive' and 'negative' impact or effect are used. These terms suggest that the tested variable preforms better (positive) or worse (negative) than the control settings (scenario A).

4.1 Experiment Irregularities

Throughout the process of the experiment errors occurred that affected the data. First, during the test of scenario B there were multiple issues with the connectivity of the lights at Store 2 and Store 4. The problems were associated with the internet signal at Location 1. This was solved by resetting the signal box that connects with the lights. To compensate for this data complication, the scenario is re-tested at the end of the experiment. The new data that is generated from re-running scenario B replaced the existing data (i.e. the data that was generated during the first run of scenario B).

A second issue started during the first week of the second-to-last test (Scenario G) at Store 8. The problem was caused by the removal of the signal box which stopped the connection with the lights. Once a signal box cannot connect with the lights, the lights will not be able to apply the selected settings and will revert to the standard light scenario at the next restart. Therefore, it is important to have the signal box functioning correctly to ensure that the lights apply the correct scenarios. This issue could not be resolved before the end of the experiment and therefore, Store 8 did not correctly participate in scenario G and repeated scenario B. The store will be excluded from further analysis.

Additionally, two stores (Store 5 and Store 6) were closed on Sundays. Therefore, the stores consistently have missing data for Sunday. It was decided to remove all data on Sunday from the data set to ensure that all stores can be compared with one another.

Finally, the experiment was conducted during the COVID-19 pandemic. Throughout the pandemic, the Dutch government has limited travel by public transportation for non-essential travel. This has greatly impacted each store location, not only in sales but also in visitors. Due to the difficulty of COVID-19, the Location 1 stores have attempted to decrease their daily costs by selectively opening their doors for certain moments of the day. In an informal interview with the manager of the Location 1 stores, it was stated that the opening hours were inconsistent and were dependent on the departing transportation, such that the store would only open for selected travel routes.

[1] As stated in Chapter 3.4, a calculation is applied to the data to compensate for store, location and weekday influences, therefore, the values do not represent actual revenue values, only a difference in test and control days.

4.2 Descriptive Statistics

In this experiment the revenue data from eight bookstores was examined on a daily basis for 12 weeks. The collected data includes total revenue (T. Rev), English book revenue (EN Boek), and Dutch Book revenue (NL Boek). The English and Dutch book revenue were selected because these product categories were presented on the tables that were highlighted by the dynamic light fixtures (see Section 3.2.1). The total revenue consisted of both the English and Dutch book revenue as well as other products in the store such as magazines, greeting cards, stationary, and food and drinks. The remaining product groups were not examined because they were not highlighted by the dynamic lighting fixtures.

Table 11 shows the descriptive statistics of the data. After the removal of data due to technical problems during the experiment or closing of stores on Sunday, the dataset includes 252 data points. For each scenario or combination of variables there are 42 data points (six days per week for seven stores).

The tables also show that the highest mean value in total revenue was 168.82 for the combination of 'cold-cold' lighting with the transition 'together', tested as scenario G (see Table 11). This means that scenario G performed better than the control scenario, resulting in a positive effect. The lowest mean value in total revenue was -135.86, for the 'warm-warm' color setting and the 'together' transition, tested as scenario E (see Table 11). Scenario E, therefore, performed negatively when compared with the control scenario. When comparing the scenarios, it appears that scenario G performed best for the total revenue (see Figure 7) as well as the English book revenue.

Table 11- Descriptive Statistics of Total Rev, EN Book Rev, and NL Book Rev.

Descriptive Statistics
Total Revenue, English Books Revenue, and Dutch Books Revenue

Color Temp	Transition	Scenario	Count	Mean T. Revenue	Mean EN Book Rev.	Mean NL Book Rev.
Warm-Cold	On Number	B	42	-81.93	-8.71	-18.03
	Together	C	42	66.06	-4.11	4.77
	Total		84	-7.94	-6.41	-6.63
Warm-Warm	On Number	D	42	-63.96	6.55	-19.35
	Together	E	42	-135.86	-15.49	-31.46
	Total		84	-99.91	-4.47	-25.40
Cold-Cold	On Number	F	42	4.41	19.47	10.74
	Together	G	42	168.82	38.56	8.68
	Total		84	86.62	29.01	9.71
Total	On Number		126	-47.16	5.77	-8.88
	Together		126	33.00	6.32	-6.00
	Total		252	-7.08	6.04	-7.44

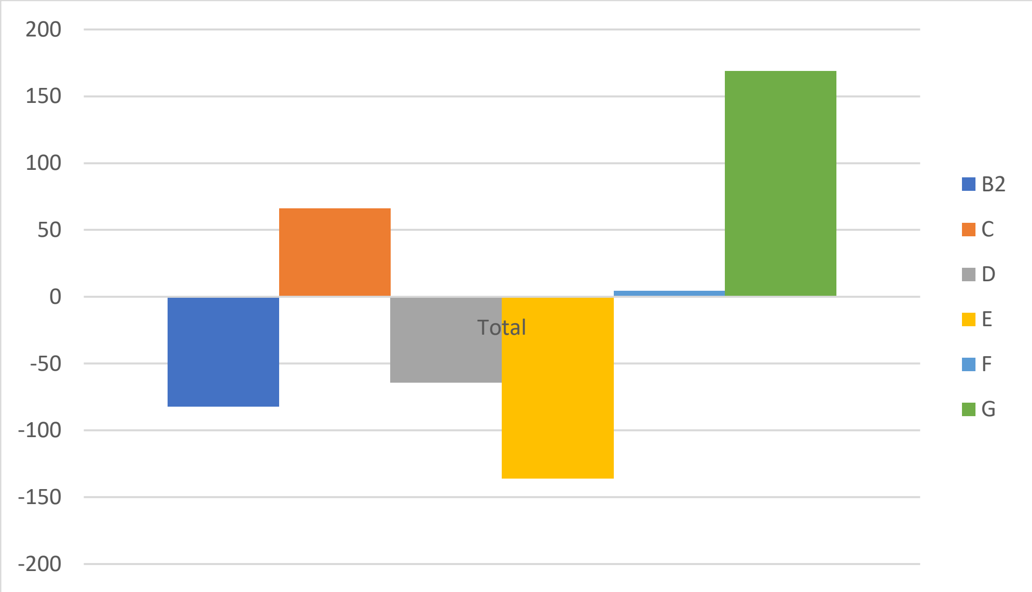

Figure 7- Average Total Revenue per Scenario

4.3 Testing Hypotheses

As described in Chapter 3.3, LMM analysis is applied to the data. This section will examine the output to test the hypotheses. The complete output is located in Appendix III: Results. The analysis is structured as follows. First, the fixed effects are examined for both variables and scenario data. Next, the individual variable level output is examined. Finally, the combination of the variable levels is examined, defined as the tested 'scenarios'.

4.3.1 Fixed Effect Output

Table 12, Table 13, and Table 14 show the type III tests of the fixed results for total revenue, English book revenue, and Dutch book revenue respectively. Based on the values in Table 12, it is derived that both the variables and scenarios are not significant predictors of total revenue. These insignificant effects are also found for English and Dutch book revenue (see Table 13 and Table 14 respectively).

Table 12- Type III Tests of Fixed Effects- Total Revenue: Variables and Scenarios

Type III Tests of Fixed Effects Total Revenue for Variables and Scenarios[a]

	Color Temperature and Transition		Scenarios	
Source	F	Sig.	F	Sig.
Intercept	.02	.88		
ColorTemp	1.25	.29		
Transition	.69	.41		
ColorTemp * Transition	.63	.54		
Intercept			.02	.88
ScenarioNr			.89	.49

a. Dependent Variable: Diff T. Rev.

Table 13- Type III Tests of Fixed Effects- EN Books: Variables and Scenarios

Type III Tests of Fixed Effects EN Books for Variables and Scenarios [a]

	Color Temperature and Transition		Scenarios	
Source	F	Sig.	F	Sig.
Intercept	.54	.46		
ColorTemp	1.94	.16		
Transition	.001	.97		
ColorTemp * Transition	.53	.59		
Intercept			.54	.46
ScenarioNr			.99	.42

a. Dependent Variable: Diff EN Boek.

Table 14- Type III Tests of Fixed Effects- NL Books: Variables and Scenarios

Type III Tests of Fixed Effects NL Books for Variables and Scenarios [a]

	Color Temperature and Transition		Scenarios	
Source	F	Sig.	F	Sig.
Intercept	.25	.62		
ColorTemp	.47	.63		
Transition	.01	.92		
ColorTemp * Transition	.12	.89		
Intercept			.25	.62
ScenarioNr			.24	.95

a. Dependent Variable: Diff NL Boek.

4.3.2 Variable Analysis Output

Table 15 presents the estimates of the variables for total revenue, English book revenue, and Dutch book revenue. The data indicates that the variable setting ‘cold-cold’ has the greatest positive effect (86.62) in the total revenue (see Table 15). The ‘warm-warm’ variable setting has the greatest negative effect (-99.91). As for the transition settings the ‘on number’ setting performs worse than the ‘together’ setting. This trend is also visible in the English and Dutch book revenue data.

Table 15- Estimated Marginal Means Color Temperature and Transition

Estimates of Variables [a]

Variable	Mean T. Rev.	Mean EN Book Rev.	Mean NL Book Rev.
Warm-Cold	-7.94	-6.41	-6.63
Warm-Warm	-99.91	-4.47	-25.40
Cold-Cold	86.62	29.01	9.71
On Number	-47.16	5.77	-8.88
Together	33.00	6.32	-6.00

a. Dependent Variable: Diff T. Rev., EN Book Rev. and NL Book Rev.

According to the pairwise comparisons of the revenue data for the variables (see Table 16), there is a marginally significant ($p < 0.10$) difference between ‘cold-cold’ and ‘warm-warm’ color temperature for total revenue. The difference becomes stronger for the English book revenue. There is no significant difference for the Dutch book revenue. The first hypothesis (*cold blueish lighting has a positive effect* *on store revenue*) is partially supported as there is a difference between 'cold-cold' lighting and both the 'warm-warm' lighting and 'warm-cold' lighting for the English book revenue but not for the total revenue. The second hypothesis is fully supported which proposed that *cold blueish lighting will have a greater positive effect on store revenue than warm reddish lighting*. As for the transition settings, there is no significant difference for Total revenue. These insignificant effects are also found for the revenue of the two product groups. Therefore, no support is found for hypothesis three which states that *transitioning light features have a positive effect on store revenue*.

Table 16- Pairwise Comparisons of Variables for Total Revenue, EN Book Rev., and NL Book Rev.

Pairwise Comparisons of Variables for Total Rev., EN Book Rev., and NL Book Rev [a]

(I) Variable	(J) Variable	Mean Difference Total Rev. (I-J)	Mean Difference EN Book Rev. (I-J)	Mean Difference NL Book Rev. (I-J)
Warm-Cold	Warm-Warm	91.98	-1.94	18.77
	Cold-Cold	-94.55	-35.42*	-16.34
Warm-Warm	Warm-Cold	-91.98	1.94	-18.77
	Cold-Cold	-186.53	-33.49**	-35.11
Cold-Cold	Warm-Cold	94.55	35.42*	16.34
	Warm-Warm	186.53*	33.49**	35.11
On Number	Together	-80.16	-0.55	-2.88
Together	On Number	80.16	0.55	2.88

Based on estimated marginal means
*$p < .10$.
**$p < .05$.
a. Dependent Variable: Diff T. Rev., Diff EN Boek, and Diff NL Boek
b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).
c. One-sided tests were applied for hypothesized effects, two-sided for non-hypothesized effects.

4.3.3 Scenario Analysis Output

Table 17 presents the estimated marginal means for the scenario test. For the total mean revenue, scenario G (variable levels cold-cold and together) has the greatest positive impact on store revenue (168.82). Scenario E (variable levels warm-warm and together) has the greatest negative impact on store revenue (-135.86). This is also visible in the English book revenue, however in the Dutch book revenue, scenario F has the greatest positive effect. This output indicates that the cold-cold light temperature does perform better than the other color temperatures.

Table 17- Estimated Marginal Means Scenarios

Estimates of Scenarios[a]

Scenario Name	Mean T. Rev.	Mean EN Book Rev.	Mean NL Book Rev.
B	-81.93	-8.71	-18.03
C	66.06	-4.11	4.77
D	-63.96	6.55	-19.35
E	-135.86	-15.49	-31.46
F	4.41	19.47	10.74
G	168.82	38.56	8.68

a. Dependent Variable: Diff T. Rev., EN Book Rev. and NL Book Rev.

The pairwise comparisons in Table 18 indicate that there is a significant difference between scenario G and E, as well as a marginally significant difference between G and D for total revenue. The difference between scenario G and E is also visible in the data for English book revenue but not for the Dutch book revenue. This again confirms the partial support for hypothesis one and full support for hypothesis two. As for hypothesis three, there is still no support, as both scenario G and E apply the same transition setting 'together' and their differences are caused by the light color temperature and not the transition. Hypothesis four proposed that *the combination of cold blueish lighting and light transition has a positive effect on store revenue*. The combination of cold lighting and the light transition 'together' resulted in positive effects on store revenue, providing support. However, this result was not visible for the 'on number' transition. Therefore, there is partial support for hypothesis four.

Table 18- Pairwise Comparisons for Scenarios

Pairwise Comparisons Scenarios[a]

(I) Scenario Nr.	(J) Scenario Nr.	Mean Difference Total Rev. (I-J)	Mean Difference EN Book Rev. (I-J)	Mean Difference NL Book Rev. (I-J)
B	C	-147.99	-4.60	-22.80
	D	-17.97	-15.25	1.32
	E	53.94	6.78	13.43
	F	-86.34	-28.18	-28.77
	G	-250.75	-47.27	-26.71
C	B	147.99	4.60	22.80
	D	130.02	-10.67	24.12
	E	201.92	11.38	36.23
	F	61.64	-23.58	-5.97
	G	-102.77	-42.67	-3.91
D	B	17.97	15.25	-1.32
	C	-130.02	10.66	-24.12
	E	71.91	22.04	12.11
	F	-68.37	-12.92	-30.09
	G	-232.78*	-32.01	-28.02
E	B	-53.94	-6.78	-13.43
	C	-201.92	-11.38	-36.23
	D	-71.91	-22.04	-12.11
	F	-140.28	-34.96	-42.20
	G	-304.69**	-54.05**	-40.13
F	B	86.34	28.18	28.77
	C	-61.64	23.58	5.97
	D	68.37	12.92	30.09
	E	140.28	34.96	42.20
	G	-164.41	-19.09	2.06
G	B	250.75	47.27	26.71
	C	102.77	42.67	3.91
	D	232.78*	32.01	28.02
	E	304.69**	54.05**	40.13
	F	164.41	19.09	-2.06

Based on estimated marginal means

*$p < .10$.

**$p < .05$.

a. Dependent Variable: Diff T. Rev., Diff EN Boek, and Diff NL Boek

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

c. One-sided tests were applied for hypothesized effects, two-sided for non-hypothesized effects.

4.4 Robustness Check

Aside from the general linear mixed model, a univariate analysis was run to test the robustness of the LMM analysis. The results of this robustness check indicate similar outcomes to the LMM analysis, in which particular 'cold-cold' color temperature performed marginally significantly better than other color temperature settings for total revenue. Again, scenario G has a positive significant difference when compared with scenario E. Also, when considering the product categories, the same pattern appeared that English book revenue does have significant results whereas the Dutch Book Revenue does not. To conclude, the univariate analysis provides robust results: hypothesis one is partially supported, hypothesis two is fully supported, the third hypothesis has no support, and the fourth hypothesis has partial support.

5 Discussion

This chapter provides the conclusion, theoretical implications, managerial implications, and the limitations and future research suggestions. In the conclusion section, the literature is summarized and linked to the results and the main research question is answered. The theoretical implications describe the added value of this study in the academic field while the managerial implications state how Invisua and retail managers can apply the knowledge from this study in their business. The limitations and future research section examine flaws and gaps in the research study and proposes new research directions that correct the identified flaws and gaps.

5.1 Conclusion

There is little literature available on dynamic lighting. The sources that examine the concept, have researched it in an office environment, which is not comparable with the retail environment (de Kort & Smolders, 2010; Logadóttir & Christoffersen, 2009). Due to the lack of literature, this study assumes that dynamic lighting would follow similar effects as the already researched lighting exhibits with additional features. An additional feature includes the changing light features. One of the assumed effects were changes in revenue due to variations in light colors (Babin et al., 2003; Bellizzi & Hite, 1992; Söker, 2009; Yildirim et al., 2007). Based on the discovered literature, the following definition for dynamic lighting was created, "the process of changing artificial light to mimic natural light and using these changes to influence (customer) behavior" (de Kort & Smolders, 2010; Logadóttir & Christoffersen, 2009). Additionally, it was stated that dynamic lighting is not a light feature on its own, it consists of changing one or more light features (Laski et al., 2020). In this thesis dynamic lighting was represented through the changes in light color temperatures and transitions within the bookstores.

The results of this study indicate that colder light color temperatures perform better than the warmer light color temperatures. This is in line with the discovered literature in Chapter 2.4.4.2 (Babin et al., 2003; Söker, 2009). However, this effect was not always visible for the individual product categories. The English book revenue had significant effects whereas the Dutch book revenue had no significant effect. This difference is interesting since both product groups are books and could be considered similar.

Possible reasons for this effect include features such as the effect of glare and sparkle (Custers et al., 2010; Society of Light and Lighting, 2009b). The covers of the books could be reflecting the light and either attracting a customer's attention (sparkle) or create a glare which causes discomfort. Another reason for this difference could be caused by book releases and promotions. Additionally, there might be a difference in the number of English and Dutch book each store displays. For example, the stores that encounter more international customers would have a greater selection of English books compared to the less international stores. In an informal interview with a business intelligence employee from the bookstore company, similar reasons were suggested for the difference between English and Dutch books. It was also suggested that differences might be caused by book releases. When new books are released, they might not immediately be released in multiple languages, leading to higher sales of the English version before the Dutch translation is published.

A second outcome indicates that the tested 'transitions' have no significant effect on store revenue, English book revenue, and Dutch book revenue. The associated literature suggested that the changes in lighting features would have a similar effect as digital displays on attraction of customer attention (Nordfält, 2011; Reynolds-McIlnay et al., 2017). This was not the case. It is possible that the tested changes in the light colors and method of transition may have been too subtle and did not successfully capture a customer's attention (Laski et al., 2020). Of course, it is possible to adjust the frequency of changes in the lighting even to the range of a stroboscope, however, this might not be an ideal situation to customers in a bookstore who wish to examine products before a purchase. To conclude, the tested transitions of lights have no effect on store revenue.

A third and final outcome from the study is that one of the tested dynamic lighting scenarios (scenario G) has shown a significant and positive relationship between the dynamic lighting and store revenue when applying cold lighting. The remaining scenarios (B through F) have not shown a significant effect. These results suggest a positive relationship between dynamic lighting and store revenue; however, it is limited to only one result. Therefore, it is difficult to state that 'dynamic lighting' as a whole has influence on store revenue. The only conclusion that can be drawn is that cold dynamic lighting has an influence on store revenue of a bookstore.

Finally, an answer is given to the main research question, *what is the impact of applying dynamic lighting in a retail store on store revenue?* From the results of this study it could be derived that, cold dynamic lighting has a positive impact on store revenue and English book revenue. This matched the color temperature lighting literature (Babin et al., 2003). There also is a positive impact on individual product revenue, however, this positive effect does not apply to all product categories. Therefore, it is concluded that the impact of applying dynamic lighting within a retail store is a positive change in store revenue. However, the effect might not be applicable to all product categories.

5.2 Theoretical Implications

The theoretical implication from this study is the addition of insight into dynamic lighting in a retail environment. The initial literature into dynamic lighting was limited to only a few sources that examined its effect in an office and work environment (de Kort & Smolders, 2010; Logadóttir & Christoffersen, 2009). The value of researching dynamic lighting in a retail setting is that customers only spend a short amount of time within a store (Bitner, 1992; Inman et al., 2009; Mari & Poggesi, 2013). The stores are dependent on the features of store atmosphere to connect with the customers and promote more purchases. Therefore, the value of store atmosphere features such as (dynamic) lighting, increases. Additionally, this study was conducted at retail locations with travelling and commuting customers, such customers often experience time scarcity (Li, Wang, Lv, & Li, 2021), reinforcing the importance of connecting with travelling customers in the short amount of time they are within the store. This study discovered a link between cold dynamic lighting and store revenue, indicating that there is value in applying dynamic lighting in a retail setting.

5.3 Managerial Implications

5.3.1 Invisua

Invisua can utilize the results from this study to increase the value of its services to its customers. The results indicate a positive relationship between cold dynamic lighting and store revenue. Also, Invisua is in possession of the so-called secret recipe of light settings that have led to the positive significant relationship between cold dynamic lighting and store revenue. This outcome can be applied as a unique selling point of the lighting systems.

Additionally, it would be of interest to expand the customer base to include other retail environments such as furniture stores or clothing stores. Dynamic lighting has the ability to mimic natural light. If the light color temperatures and transitions are applied to furniture or clothing stores, the products could be presented in a way where the customer is able to see how it appears throughout a day without leaving the store.

As for the relationship with the bookstore customer, the results are positive for the tested stores. It would be best to continue applying the colder color temperatures and transitions. Additionally, the dynamic lighting fixtures could also be applied within more bookstore locations.

5.3.2 Retail Stores

The results from the study indicate that there is an effect of dynamic cold lighting on store revenue. Retail managers have the ability to apply these findings to their stores, through adjusting their lighting settings to colder color temperatures that change over relatively short periods of time. However, the findings in this study did not indicate that the effect is significant for all product categories. The tested product categories included two similar products within one product group, namely books. Retail managers should keep in mind that the effects of dynamic lighting might not be consistent amongst all product categories.

Retail managers should also consider their brand image and target market before simply adjusting their color temperature light settings. In the literature study it was discussed that colors within a store as well as the light temperature influence a store's perceived image (Babin et al., 2003; Reddy et al., 2011; Yildirim et al., 2007). Colder colors stimulate higher purchase rates and lead to higher perceived prices (Babin et al., 2003; Söker, 2009), while warmer colors create longer shopping experiences and lower perceived prices (Babin et al., 2003; Bellizzi & Hite, 1992). Thus, a store that wishes to present themselves in a more high-end manner may consider applying warmer colors within the store to stimulate longer shopping experiences and avoid a 'cheap' perception. A lower-end store might wish to promote a sense of reliability amongst customers and a perception of low prices by applying colder dynamic lighting. Additionally, literature indicates that there are differences in cultural preferences (Davis & Ohno, 2005; Ohno, 2005). Certain cultures, such as in the Japanese culture prefer colder lighting. Colder lighting would not be preferred in North American cultures (Ohno, 2005). Retail managers should also consider the cultural factor in their stores and adjust their dynamic lighting to include cultural preferences. The color of store lighting can change a lot in a customer's perception and should not be dismissed simply to increase revenue.

5.4 Limitations and Future Research

This study is complex in nature and emphasizes the effect of dynamic retail lighting on store revenue. With the complexity of a field study, certain limitations occurred. These limitations offer directions for future research.

First, due to the format of a field study, there are many external factors that influence the data. This is a feature of field experiments as discussed in Chapter 3.1. In this study, certain external features could not be controlled for and have influenced the clarity of the results. Some features include differences in products per store, day of the week, product promotions, and COVID-19. In many journals, a laboratory experiment is a common method to study the effect of light on customer purchasing behavior (Bortz & Döring, 2006; Koschate-Fischer & Schandelmeier, 2014). Within a laboratory, external factor effects can be decreased. For a future study, it can be advised to (re)test the suggested hypotheses of this study within a laboratory experiment to allow for more internal control. Another suggestion is to extend the experiment time from two weeks per test to a couple of months. By doing this, possible seasonal trends can be controlled for.

A benefit of a field experiment is the generalizability of the results (Koschate-Fischer & Schandelmeier, 2014). This experiment examined the total revenue of the stores and the revenue of English and Dutch book sales. These are specific products making it difficult to generalize to other retail settings and products. Literature also indicates that product categories have an influence on light effects and customer behavior (Reynolds-McIlnay et al., 2017; Summers & Hebert, 2001). Therefore, it is suggested to research the effect of dynamic lighting on store revenue in different retail environments such as a clothing store, supermarket, or furniture store. Within a furniture store, dynamic lighting could allow the customer to see how the product will appear throughout the day by adjusting the light to mimic changes in daylight.

Second, the results of this study indicate a difference between the revenue of English and Dutch books when dynamic lighting is applied. It was speculated that this could be caused by differences in the covers of the books such as a glossy or matte cover or even cover colors. Future research could examine whether differences between or within product categories affect the effect of dynamic lighting on store revenue.

Third, in this study, only two light settings have been manipulated (color temperature and transition). In the field of lighting, there are many more settings that can be experimented with such as brightness and contrast. Additionally, this study selected only a few specific color temperature values to represent 'warm' and 'cold' lighting, leaving other color temperatures to be further examined. Extending this study and examining the effect of additional light settings and color temperatures on store revenue will be an interesting addition to the field of (dynamic) retail lighting.

Fourth, this experiment did not examine the random effects of the variables such as location. It is suggested that future research can examine the variables through random effects as the locations or customer base. Also, the revenue data of the other product categories can be applied to measure a possible spill-over effect from the lighting onto other product categories and their distance from the light fixtures.

Finally, this experiment was conducted during the COVID-19 pandemic. To limit the spread of the virus, certain procedures were placed inside stores. The procedures included more cleaning, providing disinfectants for the customers, and requesting customers to only touch the products they intend to purchase. This final procedure could have influenced the customers' behavior. Lighting literature indicates that store lights can increase customer approach behavior and stimulate customers to interact with the products (Reynolds-McIlnay et al., 2017; Schielke & Leudesdorff, 2015). This effect would be greatly reduced due to the COVID-19 product touching restrictions. Therefore, the results might differ from the trends indicated in literature.

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Appendices

Appendix I: Literature Background Method

Table 19- Inclusion Criteria per Literature Search Phase

Inclusion Criteria per Search Phase

Search Phase	Inclusion Criteria
3	Written in English or Dutch Digitally Available Management Focus
4	Must Provide Insight into Themes Insight of effect lighting on store revenue and human behavior
6	Provide insight to research question: *What effect can dynamic lighting in a retail setting have on store revenue?*

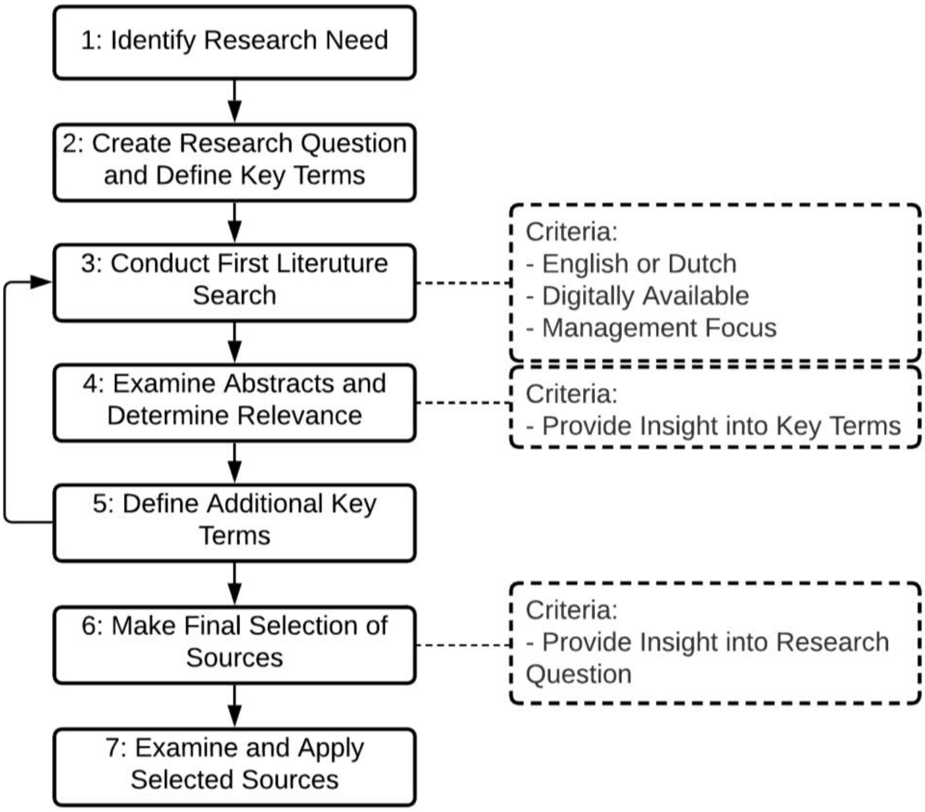

Figure 8- Literature Methodology Steps with Criteria

Appendix II: Syntax

Syntax Total Revenue

Variables and Diff T. Rev

```
MIXED DiffT.Rev BY ColorTemp Transition
  /CRITERIA=CIN(95) MXITER(100) MXSTEP(10) SCORING(1) SINGULAR(0.000000000001)
HCONVERGE(0,
    ABSOLUTE) LCONVERGE(0, ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)
  /FIXED=ColorTemp Transition ColorTemp*Transition | SSTYPE(3)
  /METHOD=ML
  /PRINT=DESCRIPTIVES
  /EMMEANS=TABLES(ColorTemp) COMPARE ADJ(LSD)
  /EMMEANS=TABLES(Transition) COMPARE ADJ(LSD)
  /EMMEANS=TABLES(ColorTemp*Transition) .
```

Scenarios and Diff T. Rev

```
MIXED DiffT.Rev BY ScenarioNr
  /CRITERIA=CIN(95) MXITER(100) MXSTEP(10) SCORING(1) SINGULAR(0.000000000001)
HCONVERGE(0,
    ABSOLUTE) LCONVERGE(0, ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)
  /FIXED=ScenarioNr | SSTYPE(3)
  /METHOD=ML
  /PRINT=DESCRIPTIVES
  /EMMEANS=TABLES(ScenarioNr) COMPARE ADJ(LSD).
```

Syntax English Books

Variables and Diff EN Books

```
MIXED DiffENBoek BY ColorTemp Transition
  /CRITERIA=CIN(95) MXITER(100) MXSTEP(10) SCORING(1) SINGULAR(0.000000000001)
HCONVERGE(0,
    ABSOLUTE) LCONVERGE(0, ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)
  /FIXED=ColorTemp Transition ColorTemp*Transition | SSTYPE(3)
  /METHOD=ML
  /PRINT=DESCRIPTIVES
  /EMMEANS=TABLES(ColorTemp) COMPARE ADJ(LSD)
  /EMMEANS=TABLES(Transition) COMPARE ADJ(LSD)
  /EMMEANS=TABLES(ColorTemp*Transition) .
```

Scenarios and Diff EN Books

```
MIXED DiffENBoek BY ScenarioNr
  /CRITERIA=CIN(95) MXITER(100) MXSTEP(10) SCORING(1) SINGULAR(0.000000000001)
HCONVERGE(0,
    ABSOLUTE) LCONVERGE(0, ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)
  /FIXED=ScenarioNr | SSTYPE(3)
  /METHOD=ML
  /PRINT=DESCRIPTIVES
  /EMMEANS=TABLES(ScenarioNr) COMPARE ADJ(LSD).
```

Syntax Dutch Books

Variables and Diff NL Books

```
MIXED DiffNLBoek BY ColorTemp Transition
  /CRITERIA=CIN(95)  MXITER(100)  MXSTEP(10)  SCORING(1)  SINGULAR(0.000000000001)
HCONVERGE(0,
    ABSOLUTE) LCONVERGE(0, ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)
  /FIXED=ColorTemp Transition ColorTemp*Transition | SSTYPE(3)
  /METHOD=ML
  /PRINT=DESCRIPTIVES
  /EMMEANS=TABLES(ColorTemp) COMPARE ADJ(LSD)
  /EMMEANS=TABLES(Transition) COMPARE ADJ(LSD)
  /EMMEANS=TABLES(ColorTemp*Transition) .
```

Scenarios and Diff NL Books

```
MIXED DiffNLBoek BY ScenarioNr
  /CRITERIA=CIN(95)  MXITER(100)  MXSTEP(10)  SCORING(1)  SINGULAR(0.000000000001)
HCONVERGE(0,
    ABSOLUTE) LCONVERGE(0, ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)
  /FIXED=ScenarioNr | SSTYPE(3)
  /METHOD=ML
  /PRINT=DESCRIPTIVES
  /EMMEANS=TABLES(ScenarioNr) COMPARE ADJ(LSD).
```

Appendix III: Results

Total Revenue Output

Variables and Diff T. Rev

Descriptive Statistics

Diff T. Rev

Color Temp	Transition	Count	Mean	Standard Deviation	Coefficient of Variation
Warm-Cold	On Number	42	-81.93	853.48	-1041.7%
	Together	42	66.06	570.52	863.7%
	Total	84	-7.94	725.37	-9139.4%
Warm-Warm	On Number	42	-63.96	1075.66	-1681.8%
	Together	42	-135.86	855.21	-629.5%
	Total	84	-99.91	966.51	-967.4%
Cold-Cold	On Number	42	4.41	676.23	15324.1%
	Together	42	168.82	444.61	263.4%
	Total	84	86.62	574.78	663.6%
Total	On Number	126	-47.16	877.39	-1860.5%
	Together	126	33.00	653.94	1981.4%
	Total	252	-7.08	773.28	-10926.6%

Model Dimension[a]

		Number of Levels	Number of Parameters
Fixed Effects	Intercept	1	1
	ColorTemp	3	2
	Transition	2	1
	ColorTemp * Transition	6	2
Residual			1
Total		12	7

a. Dependent Variable: Diff T. Rev.

Information Criteria[a]

-2 Log Likelihood	4061.66
Akaike's Information Criterion (AIC)	4075.66
Hurvich and Tsai's Criterion (AICC)	4076.12
Bozdogan's Criterion (CAIC)	4107.37
Schwarz's Bayesian Criterion (BIC)	4100.37

The information criteria are displayed in smaller-is-better form.

a. Dependent Variable: Diff T. Rev.

Fixed Effects

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	252	.02	.88
ColorTemp	2	252	1.25	.30
Transition	1	252	.69	.41

ColorTemp * Transition	2	252	.63	.54

a. Dependent Variable: Diff T. Rev.

Covariance Parameters

Estimates of Covariance Parameters[a]

Parameter	Estimate	Std. Error
Residual	585275.46	52140.48

a. Dependent Variable: Diff T. Rev.

Estimated Marginal Means

1. Color Temp

Estimates[a]

				95% Confidence Interval	
Color Temp	Mean	Std. Error	df	Lower Bound	Upper Bound
Warm-Cold	-7.94	83.47	252	-172.33	156.46
Warm-Warm	-99.91	83.47	252	-264.30	64.48
Cold-Cold	86.62	83.47	252	-77.77	251.01

a. Dependent Variable: Diff T. Rev.

Pairwise Comparisons[a]

						95% Confidence Interval for Difference[b]	
(I) Color Temp	(J) Color Temp	Mean Difference (I-J)	Std. Error	df	Sig.[b]	Lower Bound	Upper Bound
Warm-Cold	Warm-Warm	91.98	118.05	252	.44	-140.51	324.46
	Cold-Cold	-94.55	118.05	252	.42	-327.04	137.93
Warm-Warm	Warm-Cold	-91.98	118.05	252	.44	-324.46	140.51
	Cold-Cold	-186.53	118.05	252	.06	-419.01	45.96
Cold-Cold	Warm-Cold	94.55	118.05	252	.42	-137.93	327.04
	Warm-Warm	186.53	118.05	252	.06	-45.96	419.01

Based on estimated marginal means
a. Dependent Variable: Diff T. Rev.
b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Univariate Tests[a]

Numerator df	Denominator df	F	Sig.
2	252	1.25	.29

The F tests the effect of Color Temp. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.
a. Dependent Variable: Diff T. Rev.

2. Transition

Estimates[a]

				95% Confidence Interval	
Transition	Mean	Std. Error	df	Lower Bound	Upper Bound
On Number	-47.16	68.16	252	-181.38	87.07
Together	33.00	68.16	252	-101.22	167.23

a. Dependent Variable: Diff T. Rev.

Pairwise Comparisons[a]

(I) Transition	(J) Transition	Mean Difference (I-J)	Std. Error	df	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
On Number	Together	-80.16	96.39	252	.41	-269.99	109.66
Together	On Number	80.16	96.39	252	.41	-109.66	269.99

Based on estimated marginal means
a. Dependent Variable: Diff T. Rev.
b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Univariate Tests[a]

Numerator df	Denominator df	F	Sig.
1	252	.69	.41

The F tests the effect of Transition. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.
a. Dependent Variable: Diff T. Rev.

*3. Color Temp * Transition[a]*

Color Temp	Transition	Mean	Std. Error	df	95% Confidence Interval Lower Bound	Upper Bound
Warm-Cold	On Number	-81.923	118.05	252	-314.41	150.56
	Together	66.06	118.05	252	-166.43	298.54
Warm-Warm	On Number	-63.96	118.05	252	-296.44	168.53
	Together	-135.86	118.05	252	-368.35	96.62
Cold-Cold	On Number	4.41	118.05	252	-228.07	236.90
	Together	168.82	118.05	252	-63.66	401.31

a. Dependent Variable: Diff T. Rev.

Scenarios and Diff T. Rev

Descriptive Statistics

Diff T. Rev

Scenario Nr.	Count	Mean	Standard Deviation	Coefficient of Variation
B	42	-81.92	853.48	-1041.7%
C	42	66.06	570.52	863.7%
D	42	-63.95	1075.66	-1681.8%
E	42	-135.86	855.21	-629.5%
F	42	4.41	676.23	15324.1%
G	42	168.82	444.61	263.4%
Total	252	-7.08	773.28	-10926.6%

Model Dimension[a]

		Number of Levels	Number of Parameters
Fixed Effects	Intercept	1	1
	ScenarioNr	6	5
Residual			1
Total		7	7

a. Dependent Variable: Diff T. Rev.

Information Criteria[a]

-2 Log Likelihood	4061.66
Akaike's Information Criterion (AIC)	4075.66
Hurvich and Tsai's Criterion (AICC)	4076.12
Bozdogan's Criterion (CAIC)	4107.37
Schwarz's Bayesian Criterion (BIC)	4100.37

The information criteria are displayed in smaller-is-better form.
a. Dependent Variable: Diff T. Rev.

Fixed Effects

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	252	.02	.88
ScenarioNr	5	252	.89	.49

a. Dependent Variable: Diff T. Rev.

Covariance Parameters

Estimates of Covariance Parameters[a]

Parameter	Estimate	Std. Error
Residual	585275.46	52140.48

a. Dependent Variable: Diff T. Rev.

Estimated Marginal Means

Scenario Nr.

Estimates[a]

Scenario Nr.	Mean	Std. Error	df	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
B	-81.93	118.05	252	-314.41	150.56
C	66.05	118.05	252	-166.43	298.54
D	-63.96	118.05	252	-296.44	168.53
E	-135.86	118.05	252	-368.35	96.62
F	4.41	118.05	252	-228.07	236.90
G	168.82	118.05	252	-63.66	401.31

a. Dependent Variable: Diff T. Rev.

Pairwise Comparisons[a]

(I) Scenario Nr.	(J) Scenario Nr.	Mean Difference (I-J)	Std. Error	df	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	95% Confidence Interval for Difference[b] Upper Bound
B	C	-147.99	166.94	252	.38	-476.77	180.80
	D	-17.97	166.94	252	.91	-346.75	310.81
	E	53.94	166.94	252	.75	-274.85	382.72
	F	-86.34	166.94	252	.61	-415.13	242.44
	G	-250.75	166.94	252	.13	-579.53	78.03
C	B	147.99	166.94	252	.38	-180.80	476.77
	D	130.02	166.94	252	.44	-198.77	458.80
	E	201.92	166.94	252	.23	-126.86	530.70

	F	61.64	166.94	252	.71	-267.14	390.43
	G	-102.77	166.94	252	.54	-431.55	226.02
D	B	17.97	166.94	252	.91	-310.81	346.75
	C	-130.02	166.94	252	.44	-458.80	198.77
	E	71.91	166.94	252	.67	-256.88	400.69
	F	-68.37	166.94	252	.34	-397.16	260.41
	G	-232.78	166.94	252	.08	-561.56	96.00
E	B	-53.94	166.94	252	.75	-382.72	274.85
	C	-201.92	166.94	252	.23	-530.70	126.86
	D	-71.91	166.94	252	.67	-400.69	256.88
	F	-140.28	166.94	252	.20	-469.06	188.51
	G	-304.69	166.94	252	.04	-633.47	24.10
F	B	86.34	166.94	252	.61	-242.44	415.13
	C	-61.64	166.94	252	.71	-390.43	267.14
	D	68.37	166.94	252	.34	-260.41	397.16
	E	140.28	166.94	252	.20	-188.51	469.06
	G	-164.41	166.94	252	.33	-493.19	164.38
G	B	250.75	166.94	252	.13	-78.03	579.53
	C	102.77	166.94	252	.54	-226.02	431.55
	D	232.78	166.94	252	.08	-96.00	561.56
	E	304.69	166.94	252	.04	-24.10	633.47
	F	164.41	166.94	252	.33	-164.38	493.19

Based on estimated marginal means
a. Dependent Variable: Diff T. Rev.
b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Univariate Tests[a]

Numerator df	Denominator df	F	Sig.
5	252	.89	.49

The F tests the effect of Scenario Nr.. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.
a. Dependent Variable: Diff T. Rev.

English Book Revenue Output

Variables and Diff EN Books

Descriptive Statistics

Diff EN Boek

Color Temp	Transition	Count	Mean	Standard Deviation	Coefficient of Variation
Warm-Cold	On Number	42	-8.71	159.71	-1834.0%
	Together	42	-4.11	150.85	-3669.8%
	Total	84	-6.41	154.42	-2409.3%
Warm-Warm	On Number	42	6.55	152.29	2326.6%
	Together	42	-15.49	94.54	-610.4%
	Total	84	-4.47	126.47	-2828.0%
Cold-Cold	On Number	42	19.47	134.12	688.9%
	Together	42	38.56	83.82	217.4%
	Total	84	29.01	111.57	384.5%
Total	On Number	126	5.77	148.35	2571.6%
	Together	126	6.32	115.09	1821.1%
	Total	252	6.04	132.50	2192.2%

Model Dimension[a]

		Number of Levels	Number of Parameters
Fixed Effects	Intercept	1	1
	ColorTemp	3	2
	Transition	2	1
	ColorTemp * Transition	6	2
Residual			1
Total		12	7

a. Dependent Variable: Diff EN Boek.

Information Criteria[a]

-2 Log Likelihood	3172.08
Akaike's Information Criterion (AIC)	3186.08
Hurvich and Tsai's Criterion (AICC)	3186.53
Bozdogan's Criterion (CAIC)	3217.78
Schwarz's Bayesian Criterion (BIC)	3210.78

The information criteria are displayed in smaller-is-better form.

a. Dependent Variable: Diff EN Boek.

Fixed Effects

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	252	.54	.46
ColorTemp	2	252	1.94	.15
Transition	1	252	.001	.97
ColorTemp * Transition	2	252	.53	.59

a. Dependent Variable: Diff EN Boek.

Covariance Parameters

Estimates of Covariance Parameters[a]

Parameter	Estimate	Std. Error
Residual	17149.44	1527.80

a. Dependent Variable: Diff EN Boek.

Estimated Marginal Means

1. Color Temp

Estimates[a]

				95% Confidence Interval	
Color Temp	Mean	Std. Error	df	Lower Bound	Upper Bound
Warm-Cold	-6.41	14.29	252	-34.55	21.73
Warm-Warm	-4.47	14.29	252	-32.61	23.67
Cold-Cold	29.01	14.29	252	.87	57.15

a. Dependent Variable: Diff EN Boek.

Pairwise Comparisons[a]

						95% Confidence Interval for Difference[b]	
(I) Color Temp	(J) Color Temp	Mean Difference (I-J)	Std. Error	df	Sig.[b]	Lower Bound	Upper Bound
Warm-Cold	Warm-Warm	-1.94	20.21	252	.92	-41.73	37.86
	Cold-Cold	-35.42	20.21	252	.08	-75.22	4.37
Warm-Warm	Warm-Cold	1.94	20.21	252	.92	-37.86	41.73
	Cold-Cold	-33.49	20.21	252	.05	-73.28	6.31
Cold-Cold	Warm-Cold	35.42	20.21	252	.08	-4.37	75.22
	Warm-Warm	33.49	20.21	252	.05	-6.31	73.28

Based on estimated marginal means

a. Dependent Variable: Diff EN Boek.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Univariate Tests[a]

Numerator df	Denominator df	F	Sig.
2	252	1.94	.15

The F tests the effect of Color Temp. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Dependent Variable: Diff EN Boek.

2. Transition

Estimates[a]

				95% Confidence Interval	
Transition	Mean	Std. Error	df	Lower Bound	Upper Bound
On Number	5.77	11.67	252	-17.21	28.75
Together	6.32	11.67	252	-16.66	29.30

a. Dependent Variable: Diff EN Boek.

Pairwise Comparisons[a]

						95% Confidence Interval for Difference[b]	
(I) Transition	(J) Transition	Mean Difference (I-J)	Std. Error	df	Sig.[b]	Lower Bound	Upper Bound

On Number	Together	-.55	16.50	252	.97	-33.04	31.94
Together	On Number	.55	16.50	252	.97	-31.94	33.04

Based on estimated marginal means
a. Dependent Variable: Diff EN Boek.
b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Univariate Tests[a]

Numerator df	Denominator df	F	Sig.
1	252	.001	.97

The F tests the effect of Transition. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.
a. Dependent Variable: Diff EN Boek.

*3. Color Temp * Transition*[a]

					95% Confidence Interval	
Color Temp	Transition	Mean	Std. Error	df	Lower Bound	Upper Bound
Warm-Cold	On Number	-8.71	20.21	252	-48.50	31.09
	Together	-4.11	20.21	252	-43.91	35.69
Warm-Warm	On Number	6.55	20.21	252	-33.25	46.34
	Together	-15.49	20.21	252	-55.29	24.31
Cold-Cold	On Number	19.47	20.21	252	-20.33	59.27
	Together	38.56	20.21	252	-1.24	78.36

a. Dependent Variable: Diff EN Boek.

Scenarios and Diff EN Books

Descriptive Statistics
Diff EN Boek

Scenario Nr.	Count	Mean	Standard Deviation	Coefficient of Variation
B	42	-8.71	159.71	-1834.0%
C	42	-4.11	150.85	-3669.8%
D	42	6.55	152.29	2326.6%
E	42	-15.49	94.54	-610.4%
F	42	19.47	134.12	688.9%
G	42	38.56	83.82	217.4%
Total	252	6.04	132.50	2192.2%

Model Dimension[a]

		Number of Levels	Number of Parameters
Fixed Effects	Intercept	1	1
	ScenarioNr	6	5
Residual			1
Total		7	7

a. Dependent Variable: Diff EN Boek.

Information Criteria[a]

-2 Log Likelihood	3172.08
Akaike's Information Criterion (AIC)	3186.08

Hurvich and Tsai's Criterion (AICC)	3186.53
Bozdogan's Criterion (CAIC)	3217.78
Schwarz's Bayesian Criterion (BIC)	3210.78

The information criteria are displayed in smaller-is-better form.
a. Dependent Variable: Diff EN Boek.

Fixed Effects

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	252	.54	.46
ScenarioNr	5	252	.99	.42

a. Dependent Variable: Diff EN Boek.

Covariance Parameters

Estimates of Covariance Parameters[a]

Parameter	Estimate	Std. Error
Residual	17149.44	1527.79

a. Dependent Variable: Diff EN Boek.

Estimated Marginal Means

Scenario Nr.

Estimates[a]

				95% Confidence Interval	
Scenario Nr.	Mean	Std. Error	df	Lower Bound	Upper Bound
B	-8.71	20.207	252	-48.50	31.09
C	-4.11	20.207	252	-43.91	35.69
D	6.55	20.207	252	-33.25	46.34
E	-15.49	20.207	252	-55.29	24.31
F	19.47	20.207	252	-20.33	59.27
G	38.56	20.207	252	-1.24	78.36

a. Dependent Variable: Diff EN Boek.

Pairwise Comparisons[a]

						95% Confidence Interval for Difference[b]	
(I) Scenario Nr.	(J) Scenario Nr.	Mean Difference (I-J)	Std. Error	df	Sig.[b]	Lower Bound	Upper Bound
B	C	-4.60	28.58	252	.87	-60.88	51.68
	D	-15.25	28.58	252	.59	-71.53	41.03
	E	6.78	28.58	252	.81	-49.50	63.06
	F	-28.18	28.58	252	.33	-84.46	28.10
	G	-47.27	28.58	252	.10	-103.55	9.01
C	B	4.60	28.58	252	.87	-51.68	60.88
	D	-10.66	28.58	252	.71	-66.94	45.62
	E	11.38	28.58	252	.69	-44.90	67.66
	F	-23.58	28.58	252	.41	-79.86	32.70
	G	-42.67	28.58	252	.14	-98.95	13.61
D	B	15.25	28.58	252	.59	-41.03	71.53

	C	10.66	28.58	252	.71	-45.62	66.94
	E	22.04	28.58	252	.44	-34.25	78.32
	F	-12.92	28.58	252	.33	-69.20	43.36
	G	-32.01	28.58	252	.13	-88.29	24.27
E	B	-6.78	28.58	252	.81	-63.06	49.50
	C	-11.38	28.58	252	.69	-67.66	44.90
	D	-22.04	28.58	252	.44	-78.32	34.25
	F	-34.96	28.58	252	.11	-91.24	21.32
	G	-54.05	28.58	252	.03	-110.33	2.23
F	B	28.18	28.58	252	.33	-28.10	84.46
	C	23.58	28.58	252	.41	-32.70	79.86
	D	12.92	28.58	252	.33	-43.36	69.20
	E	34.96	28.58	252	.11	-21.32	91.24
	G	-19.09	28.58	252	.51	-75.37	37.19
G	B	47.27	28.58	252	.10	-9.01	103.55
	C	42.67	28.58	252	.14	-13.61	98.95
	D	32.01	28.58	252	.13	-24.27	88.29
	E	54.05	28.58	252	.03	-2.23	110.33
	F	19.09	28.58	252	.51	-37.19	75.37

Based on estimated marginal means
a. Dependent Variable: Diff EN Boek.
b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Univariate Tests[a]

Numerator df	Denominator df	F	Sig.
5	252	.99	.42

The F tests the effect of Scenario Nr. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.
a. Dependent Variable: Diff EN Boek.

Dutch Book Revenue Output

Variables and Diff NL Books

Descriptive Statistics

Diff NL Boek

Color Temp	Transition	Count	Mean	Standard Deviation	Coefficient of Variation
Warm-Cold	On Number	42	-18.03	231.31	-1282.9%
	Together	42	4.77	254.23	5329.2%
	Total	84	-6.63	241.84	-3647.7%
Warm-Warm	On Number	42	-19.35	234.11	-1210.1%
	Together	42	-31.46	279.72	-889.2%
	Total	84	-25.40	256.44	-1009.5%
Cold-Cold	On Number	42	10.74	217.52	2025.6%
	Together	42	8.68	207.43	2390.5%
	Total	84	9.71	211.25	2176.1%
Total	On Number	126	-8.88	226.36	-2549.2%
	Together	126	-6.00	247.60	-4124.7%
	Total	252	-7.44	236.75	-3181.6%

Model Dimension[a]

		Number of Levels	Number of Parameters
Fixed Effects	Intercept	1	1
	ColorTemp	3	2
	Transition	2	1
	ColorTemp * Transition	6	2
Residual			1
Total		12	7

a. Dependent Variable: Diff NL Boek.

Information Criteria[a]

-2 Log Likelihood	3468.33
Akaike's Information Criterion (AIC)	3482.33
Hurvich and Tsai's Criterion (AICC)	3482.79
Bozdogan's Criterion (CAIC)	3514.03
Schwarz's Bayesian Criterion (BIC)	3507.03

The information criteria are displayed in smaller-is-better form.

a. Dependent Variable: Diff NL Boek.

Fixed Effects

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	252	.25	.61
ColorTemp	2	252	.47	.63
Transition	1	252	.01	.92

ColorTemp * Transition	2	252	.12	.89

a. Dependent Variable: Diff NL Boek.

Covariance Parameters

Estimates of Covariance Parameters[a]

Parameter	Estimate	Std. Error
Residual	55566.08	4950.22

a. Dependent Variable: Diff NL Boek.

Estimated Marginal Means

1. Color Temp

Estimates[a]

				95% Confidence Interval	
Color Temp	Mean	Std. Error	df	Lower Bound	Upper Bound
Warm-Cold	-6.63	25.72	252	-57.28	44.02
Warm-Warm	-25.40	25.72	252	-76.06	25.25
Cold-Cold	9.71	25.72	252	-40.95	60.36

a. Dependent Variable: Diff NL Boek.

Pairwise Comparisons[a]

						95% Confidence Interval for Difference[b]	
(I) Color Temp	(J) Color Temp	Mean Difference (I-J)	Std. Error	df	Sig.[b]	Lower Bound	Upper Bound
Warm-Cold	Warm-Warm	18.77	36.37	252	.61	-52.86	90.41
	Cold-Cold	-16.34	36.37	252	.65	-87.97	55.30
Warm-Warm	Warm-Cold	-18.77	36.37	252	.61	-90.41	52.86
	Cold-Cold	-35.11	36.37	252	.34	-106.74	36.52
Cold-Cold	Warm-Cold	16.34	36.37	252	.65	-55.30	87.97
	Warm-Warm	35.11	36.37	252	.34	-36.52	106.74

Based on estimated marginal means
a. Dependent Variable: Diff NL Boek.
b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Univariate Tests[a]

Numerator df	Denominator df	F	Sig.
2	252	.47	.63

The F tests the effect of Color Temp. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.
a. Dependent Variable: Diff NL Boek.

2. Transition

Estimates[a]

				95% Confidence Interval	
Transition	Mean	Std. Error	df	Lower Bound	Upper Bound
On Number	-8.88	21.00	252	-50.24	32.48
Together	-6.00	21.00	252	-47.36	35.36

a. Dependent Variable: Diff NL Boek.

Pairwise Comparisons[a]

(I) Transition	(J) Transition	Mean Difference (I-J)	Std. Error	df	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
On Number	Together	-2.88	29.70	252	.92	-61.37	55.61
Together	On Number	2.88	29.70	252	.92	-55.61	61.37

Based on estimated marginal means
a. Dependent Variable: Diff NL Boek.
b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Univariate Tests[a]

Numerator df	Denominator df	F	Sig.
1	252	.01	.92

The F tests the effect of Transition. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.
a. Dependent Variable: Diff NL Boek.

*3. Color Temp * Transition[a]*

Color Temp	Transition	Mean	Std. Error	df	95% Confidence Interval Lower Bound	Upper Bound
Warm-Cold	On Number	-18.03	36.37	252	-89.66	53.60
	Together	4.77	36.37	252	-66.86	76.40
Warm-Warm	On Number	-19.35	36.37	252	-90.98	52.29
	Together	-31.46	36.37	252	-103.09	40.18
Cold-Cold	On Number	10.74	36.37	252	-60.90	82.37
	Together	8.68	36.37	252	-62.96	80.31

a. Dependent Variable: Diff NL Boek.

Scenarios and Diff NL Books

Descriptive Statistics

Diff NL Boek

Scenario Nr.	Count	Mean	Standard Deviation	Coefficient of Variation
B	42	-18.03	231.31	-1282.9%
C	42	4.77	254.23	5329.2%
D	42	-19.35	234.11	-1210.1%
E	42	-31.46	279.72	-889.2%
F	42	10.74	217.52	2025.6%
G	42	8.68	207.43	2390.5%
Total	252	-7.44	236.75	-3181.6%

Model Dimension[a]

		Number of Levels	Number of Parameters
Fixed Effects	Intercept	1	1
	ScenarioNr	6	5
Residual			1
Total		7	7

a. Dependent Variable: Diff NL Boek.

Information Criteria[a]

-2 Log Likelihood	3468.33
Akaike's Information Criterion (AIC)	3482.33
Hurvich and Tsai's Criterion (AICC)	3482.79
Bozdogan's Criterion (CAIC)	3514.03
Schwarz's Bayesian Criterion (BIC)	3507.03

The information criteria are displayed in smaller-is-better form.
a. Dependent Variable: Diff NL Boek.

Fixed Effects

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	252	.25	.62
ScenarioNr	5	252	.24	.95

a. Dependent Variable: Diff NL Boek.

Covariance Parameters

Estimates of Covariance Parameters[a]

Parameter	Estimate	Std. Error
Residual	55566.08	4950.22

a. Dependent Variable: Diff NL Boek.

Estimated Marginal Means

Scenario Nr.

Estimates[a]

				95% Confidence Interval	
Scenario Nr.	Mean	Std. Error	df	Lower Bound	Upper Bound
B	-18.03	36.37	252	-89.66	53.60
C	4.77	36.37	252	-66.86	76.40
D	-19.35	36.37	252	-90.98	52.29
E	-31.46	36.37	252	-103.09	40.18
F	10.74	36.37	252	-60.90	82.37
G	8.68	36.37	252	-62.96	80.31

a. Dependent Variable: Diff NL Boek.

Pairwise Comparisons[a]

						95% Confidence Interval for Difference[b]	
(I) Scenario Nr.	(J) Scenario Nr.	Mean Difference (I-J)	Std. Error	df	Sig.[b]	Lower Bound	Upper Bound
B	C	-22.80	51.44	252	.66	-124.11	78.51
	D	1.32	51.44	252	.98	-99.99	102.62
	E	13.43	51.44	252	.79	-87.88	114.73
	F	-28.77	51.44	252	.58	-130.08	72.54
	G	-26.71	51.44	252	.60	-128.01	74.60
C	B	22.80	51.44	252	.66	-78.51	124.11
	D	24.12	51.44	252	.64	-77.19	125.42
	E	36.23	51.44	252	.48	-65.08	137.53

	F	-5.97	51.44	252	.91	-107.27	95.34
	G	-3.91	51.44	252	.94	-105.21	97.40
D	B	-1.32	51.44	252	.98	-102.62	99.99
	C	-24.12	51.44	252	.64	-125.42	77.19
	E	12.11	51.44	252	.81	-89.20	113.42
	F	-30.09	51.44	252	.28	-131.39	71.22
	G	-28.02	51.44	252	.29	-129.33	73.28
E	B	-13.43	51.44	252	.79	-114.73	87.88
	C	-36.23	51.44	252	.48	-137.53	65.08
	D	-12.11	51.44	252	.81	-113.42	89.20
	F	-42.20	51.44	252	.21	-143.50	59.11
	G	-40.13	51.44	252	.22	-141.44	61.17
F	B	28.77	51.44	252	.58	-72.54	130.08
	C	5.97	51.44	252	.91	-95.34	107.27
	D	30.09	51.44	252	.28	-71.22	131.39
	E	42.20	51.44	252	.21	-59.11	143.50
	G	2.06	51.44	252	.97	-99.25	103.37
G	B	26.71	51.44	252	.60	-74.60	128.01
	C	3.91	51.44	252	.94	-97.40	105.21
	D	28.02	51.44	252	.29	-73.28	129.33
	E	40.13	51.44	252	.22	-61.17	141.44
	F	-2.06	51.44	252	.97	-103.37	99.25

Based on estimated marginal means
a. Dependent Variable: Diff NL Boek.
b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Univariate Tests[a]

Numerator df	Denominator df	F	Sig.
5	252	.24	.95

The F tests the effect of Scenario Nr. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.
a. Dependent Variable: Diff NL Boek.