

IMPACT OF CORRELATED COLOUR TEMPERATURE ON USER'S TIME PERCEPTION AND EMOTIONAL STATE:

An experimental study with reference to fast-food outlets

Background

Time is one of the most valuable resources in the world and is one of the most controversial concepts that can be discussed at experiential, conceptual, and philosophical levels. Concepts of time were recognizable even before the 19th century and most of the time its' importance depends on the uniqueness of the moment or the irreversible factor of its perceptible nature. Keeping track of time in space is a key component of living beings, which intentionally or unintentionally contributes to maintaining and concentrating attention, health, and well-being [1]- [4]. Due to rapid development and globalization, people are used to relying on mechanical clocks and clock time rather than brain time. These behavioral patterns and global movements influence people to deviate from their natural senses. Discouraging sensory stimuli to function at their full capacity can cause a range of diseases and impairments. Therefore, encouraging human senses is essential for health and good performance. Studies have shown that the deliberate use of sensory cues can influence the brain's timing mechanism to encourage or discourage its processing [5]-[8]. Accordingly, it is vital to recognize these brain time manipulative factors for their conducive incorporation in an intuitively constructed environment. Even if time influences individuals' emotions and behavior in built spaces, this notion has not been thoroughly discussed in the Architectural research domain. The sensory cues are mainly dominated by the visual cues of the contemporary world [9]. Among those visual cues, colour and lighting hold significant value in both natural and built environments [2]. This research primarily builds upon four well-structured research questions given below.

1. Why do perceptions of passage of time vary with different places or spaces?
2. What are the possible connections between spatial perception and time perception?
3. Can visual stimuli manipulate users' perception of time intervals and emotions?
4. What is the role of colour and lighting as significant visual cues in the correlation between time space perception?

This research attempts to compile a full spectrum of factors that contribute to the perception of space and time in built spaces and focuses on determining the impact of visual stimulants on user's time perception with special reference to Correlated Colour Temperature (CCT), a relationship which has been least investigated.

Model development

The study implemented a virtual simulation method to expedite the data collection process. The main part of the study comprised of examining participants' interval timing judgments/perceptions under three different CCT levels. A service envi-

ronment was chosen as the building typology to be studied of which the related function was dining facility, with special reference to fast food outlets. Scalar Expectancy Theory (SET) was adopted in this investigation to theoretically construct the relationship between spatial perception and time perception. SET is a major and dominant theoretical framework also identified as a pacemaker accumulator model which was originally proposed by Gibbon in 1977 [10] and evolved by the work of colleagues and scholars into the most successful theory to explain interval judgments in animals and humans [11]. The study of interval timing was focused on the second-to-minute time scale which also contributes to interpreting the results with SET.

Table 1: Research Design

Case study	A selected fast-food outlet located in Moratuwa
Setup & space of implementation	Replicated the interior 3D environment of a selected fast-food outlet located in Moratuwa
Type of participants	Undergraduates (B. Arch - Level 5)
Number of participants	30: 72% - Male, 34% - Female, 4% - Other
Mode of implementation	An online questionnaire and a 5-minute sequence simulated environmental images (GIF).
Number of experiential setups	3 experimental settings with reference to warm CCT (2000K), neutral CCT (5500K) and cool CCT (10000K) colour temperatures.
Total time allocation	7 days
Time allocation for one participant in one scenario (setup)	10 -15 minutes
Time allocation for one scenario (setup)	1 day
Conducting the implementation process – field work	Study actual environment and relative measures. Online questionnaire 3D image sequence used
Data collection Methods	Online questionnaire and interviews, VR method
Data collection Instruments	Waiting time attitude Time perception Pleasure, Arousal, Dominance (PAD) Scale - Emotional State Evaluate space (3 combined scales: active/ comfortable/messy) Cognitive preference (participant opinion)
Data analysis	Manual and SPSS

This research is the first research to study interval time perception in Architectural research domain with reference to Sri Lankan geo-cultural context.

To detect the emotional impact of the experience in the simulated environment under set CCT levels, the corresponding emotional states of the participants were measured adopting PAD emotional state psychological model developed by Mehrabian & Russell in 1974, which uses three numerical dimensions; Pleasure, Arousal and Dominance to represent all emotions [12]. A questionnaire was adopted to measure the overall evaluation of the simulation space, which was developed using data collection instruments derived from previous scholarly studies. The table below shows the overview of the research design.

Methodology

It is widely accepted that the multinational fast-food outlets maintain a good ambient environment in and around the outlets and people show more attraction towards environmental elements and their colours [13]. A virtual environment was created by simulating an existing indoor environment of a fast-food outlet in Moratuwa. Research conducted related to fast food consumption and consumer behavior provides an abstract overview of the Sri Lankans fast food culture and based on that this

research focused more on youth and university students [13],[14]. Survey participants volunteered from level 5 Architecture undergraduates of the University of Moratuwa representing a cross section of different sociocultural groups of the Sri Lankan society.

Three levels of CCT; 2000K (warm), 5500K (neutral), and 10000K (cool) were incorporated in the virtual environment and evaluated for time perception. The colours of the existing environment were kept unchanged in the experimental setup. Existing Furniture, finishes, textures, and other elements were used as much as possible to recreate the actual situation. Colour values were applied by extracting colours from actual photographs. The virtual environment model was rendered using the Lumion 12.0 rendering engine and only artificial lighting was used for the investigation. 7 nos. of Lamp 24 (cone angle 137.5, 20 value brightness with dynamic shadows) lights were used for the general lighting and 4 nos. of Lamp 30 (cone angle 137.5, 20 value brightness with dynamic shadows) lights were used for fixtures shown in the dining area. In the cashier counter, 3 nos. of Lamp 28 lights were used (cone angle 137.5, 20 value brightness with dynamic shadows). For the preparation area, 2 nos. area lights (1m x 1m) and one line light (3m x 0.2m) were used with a 20-value brightness.



Figure 1: Existing status of the selected fast-food outlet: View 01



Figure 2: Simulated VR model: View 01



Figure 3: Existing status of the selected fast-food outlet: View 02

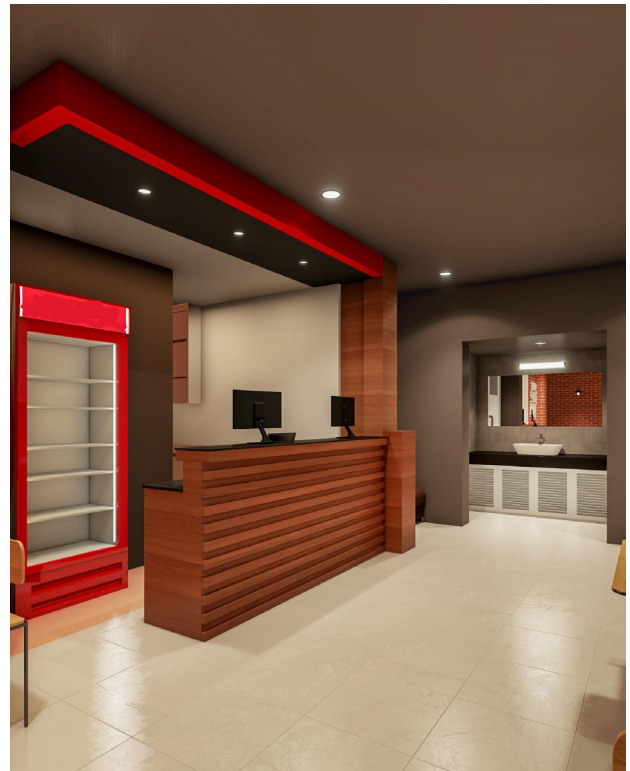


Figure 4: Simulated VR model: View 02

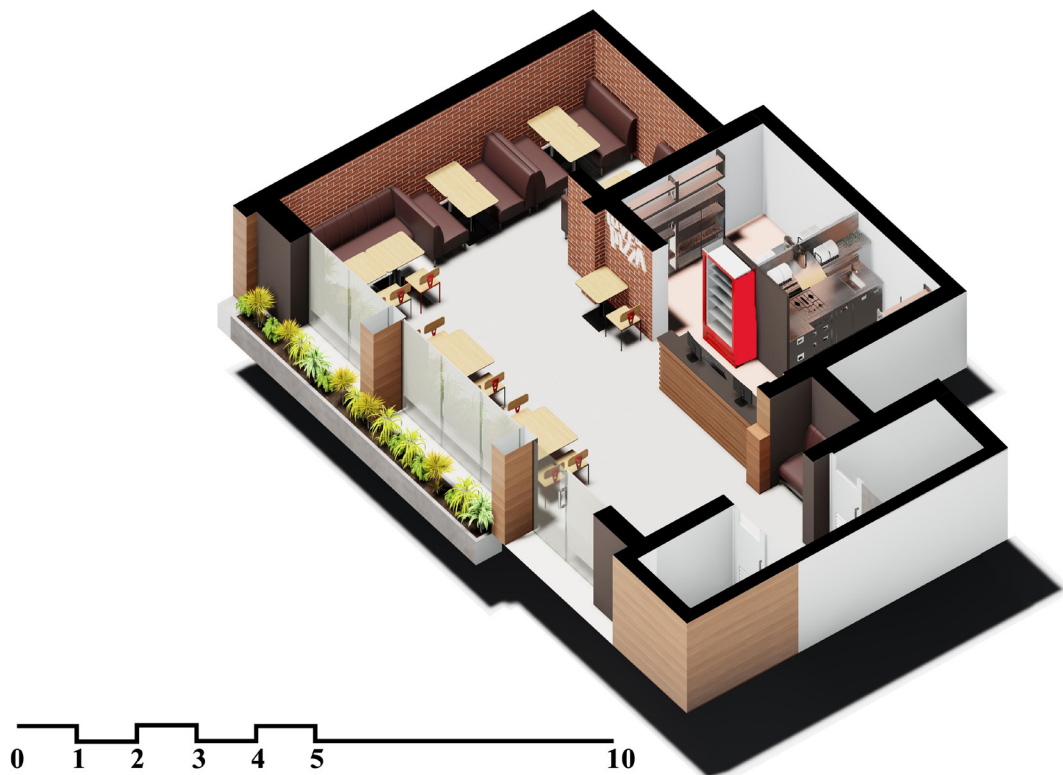


Figure 5: Simulated VR Model of the selected fast-food outlet –Moratuwa

Data collection was executed through an online survey adopting Virtual Reality technology (VR). Virtual image sequences (GIF) were used with five-minute time intervals to expose the participants to the three experimental scenarios. The participants were instructed to respond to a questionnaire with three-sections per CCT exposure,

Section 1: Time perception and time interval judgment

Section 2: Pleasure, Arousal, Dominance (PAD) Scale

Section 3: Preferred correlated colour temperature level and their opinion about experiences

Further, basic demographic information of participants was collected, and participants were interviewed to further identify their experiences per scenarios tested. An ordinal regression model was adopted to analyze the data.

Findings, conclusions, and way forward

The study revealed that the CCT levels have a small yet clear effect on the perception of the waiting time. The ordinary regression model demonstrated statistically significant results with reference to warm 2000K CCT scenario tested [$X^2(1) = 4.271, P=0.056$] signifying a direct relationship to time perception. PAD levels also demonstrated a relative variation with the CCT levels; arousal [$X^2(1) = 8.482, P=0.004$] and dominance [$X^2(1) = 6.050, P=0.014$] showing statistically significant results for time perception.

The research findings highlight the tendency for time perception to be manipulated by CCT. The increase of the CCT levels were found to be associated with relatively shorter value in the perceived interval timing period as compared to the absolute clock time. A majority of the subjects (56%) preferred the scenario with a neutral CCT level over warm (27%) and cool scenarios (17%) tested. As the CCT values increase, the participants showed a lack of interest in the perceived spatial character of the simulated fast-food outlet.

The findings of this study shed light on the optimal use of CCT levels to create more pleasurable, and comfortable dining experiences with a conducive time perception in fast-food outlets. To derive a generalized theoretical position, it is suggested to further examine this concept with diverse samples in large numbers without the influence of gender as a parameter [15]. Furthermore, for future studies in a physical context, this research encourages the selection of contrasting CCT levels with appropriate light sources and increasing waiting time to longer than 15 minutes [6] for an in-depth understanding of interval time perception in built environment.

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