

Workplace Perception Based on Virtual Office Design Using Eye Tracker

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ABSTRACT

This study aims to create a safe office space design concept in accordance with the perceptions of people in Indonesia based on the stimulus provided through an eye tracker. The study analysis referred to the results of the area

of interest from eye fixation and the SEM-PLS statistical analysis of the self-reported results, and conclusions were drawn based on the results of the statistical analysis with P-values and T-statistic on the three hypotheses. The results indicate that perceptions of ETB and SRB influence office space design stimulus, showing the importance of workplace perception as a “safe place” in terms of managing spatial attributes to protect oneself during a pandemic.

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Introduction

The COVID-19 pandemic has changed many conditions, strategies, and daily behaviors, including working conditions. The high risk of disease transmission in office buildings has changed the way offices work and the design itself. Even though the COVID-19 pandemic is said to have ended, psychological effects such as pandemic fatigue experienced by a person have changed his emotions and feelings, affecting his perception of his work (uclahealth, 2020). According to the WHO, most people in Indonesia have experienced fatigue due to the pandemic, which is characterized by low adherence to health protocols. This has an impact on the strategy to reduce the number of COVID-19 cases in Indonesia. To survive the pandemic, the adherence rate must increase to 75% of the population.

The high number of COVID-19 cases has prompted many office design recommendations to prevent transmission. However, the safety and effectiveness of this design for its users have not been scientifically tested. The effectiveness of an architectural design is usually determined by measuring the comfort of its users. The experience of space engages all of the user's senses (Spence, 2020). According to Heilig's ranking, the percentage performance of our senses in exploring spatial experiences is 70% seeing, 20% listening, 5% smelling, 4% touching, and 1% tasting (Heilig, 1992). As Hebb's law says, neurons that fire together are connected together. As a result, they more often behave in the same situation (Calbet, 2020). The involvement of the human senses in forming spatial perceptions is still dominated by what they see. Until the emergence of ocular centrism, which was discussed by Pallasmaa, Eyecentrism is able to create an understanding of one's inner environment (Pallasmaa, 2012).

Eye tracker technology has been used in the world of architecture to translate psychological conditions into the neural processes that occur in a person when they react to something. There are three main aspects that can be measured by an eye tracker, including gaze, saccade, and fixation (Mahmoud et al., 2022). The pandemic era has pushed architecture to make spaces more functional and dynamic (Perren and Mlecek, 2022). Several workplace designs have emerged to meet specific

job requirements during the pandemic. Many designs have been proposed, but the perception experienced by users has not been scientifically proven.

Many psychological problems that affect human behavior arise in outer space. However, no research has identified the issue of pandemic fatigue in a spatial context. This study examines people's perceptions of the workplace when experiencing fatigue due to a pandemic. The eye tracker will be used to pinpoint areas of interest by repairing spaces in office buildings that have undergone changes during the pandemic. This research resulted in a safe office space design concept in accordance with the perceptions of the people in Indonesia and based on the stimulus provided through the use of an eye tracker. The results of the research are in the form of recommendations for structuring objects in the design of workplaces in office buildings for architects and municipalities in dealing with future pandemics.

The first research question is whether there is a relationship between people's perception of visual stimuli and the fatigue experienced by the pandemic. The second research question is whether people's perceptions of office designs made according to pandemic-era design guidelines have increased. While the three hypotheses formulated are:

H1: Visual perception based on the eye tracker (ETB) influences the design of office space.

H2: Self-reported-based visual perception (SRB) influences office space design

H3: relationship between self-report and eye tracking of visual perception

Material and Methods

a. Perception of office space design for pandemic fatigue workers.

Office space can be open or closed, for individuals or groups (Neufert et al., 2012). Office space can consist of various rooms such as a reception room (lobby), work space (private and for groups), service room (including the entrance), archive room and meeting room (meeting room).

During a pandemic, workplace adjustments are necessary to reduce fatigue and the spread of disease. This adaptation is linked to environmental and worker health determinants. Therefore, managers must optimally respond to increased stress by providing a flexible and supportive work environment, adapting communication methods, and employing various strategies to coordinate and maintain their relationships with employees effectively (Axe et al., 2022).

Reducing the impact of worker fatigue during a pandemic requires flexible office design solutions. This is to ensure that the office can be used effectively for coordination and communication between workers. Good office design should reduce boredom at work. It is important to pay attention when someone has to work because of illness or disability, including improving the quality of life and well-being (Waddell & Burton, 2007). Unfortunately, data shows that many pre-pandemic jobs did not support optimal well-being or productivity, especially for young people (Parry et al., 2022). Standards of mental quality in the workplace need to be improved by completing the architectural design of the office space.

b. Changes in office design during the pandemic to ensure essential workplace design requirements.

Various phenomena of change that can occur in the work space need to be identified and varied to measure perceptual variables. Working from home (WFH) during a pandemic causes a decrease in physical and mental well-being (Xiao et al., 2021). Perceived stress and fatigue tend to be higher than before COVID-19 (Hayes et al., 2021). For office workers, the situation is not much different.

The World Health Organization (WHO) provides recommendations for preventing the transmission of COVID-19 in the workplace, including: 1) work distance restrictions must be implemented to reduce workplace density; 2) Setting quotas for office space occupants to limit density and physical contact, 3). Restrictions on social activities and all personal functions; 4); meal breaks prepared independently from home; and 5). Alternative work is recommended. Physical restrictions at work to minimize physical contact are mandatory in several government offices as a condition for reopening (WHO, 2021). Health protocol guidelines need to be communicated both orally and visually on an ongoing basis.

The criteria for the attractiveness of the ten office designs are: 1) input (E); 2) Lobby (L), 3 Administration Room (AD). This area was the first to see changes in activity during the pandemic. Creating one-way streets and social distancing designs by creating physical barriers to the workplace can be a future solution for office designs (Baker, 2021; Karlsruhe, 2020).

The workplace is divided into two functions: 4). Community workspace (CWS) and 5). Individual studies (IWS) (Panero and Zelnik, 1979). Surveys at several companies found that employees want a better workplace, which may provide reasons why working in an office is better than working at home. This includes rooms for various tasks such as quiet zones, quiet zones, and collaboration spaces, which can be taken into account when designing work environments. Workers expect a workplace that supports their work and not just a place to spend their working hours (mittie, 2022). 6). Meeting room (MR) requires determination of room capacity. 7). Activity support areas such as the Sport Area (SA) according to WHO recommendations for 150 minutes of moderate physical activity or 75 minutes of vigorous physical activity per week. Especially in times of fear and crisis, regular exercise can prove very helpful (UN, 2020). 8). Applied innovation technology during a pandemic such as UV Robot (UVR). Robots are playing an important role worldwide in the fight against the SARS-CoV-2 coronavirus. UVD disinfection robots, for example, have been in great demand since the outbreak of the Covid-19 pandemic (frankfrut, 2020). 9). Circulation Activity (AC) and 10). The latest office design reference in Indonesia (LO). New work standards for office design include increasing the distance between workstations, reducing the number of seats to reduce occupancy, using high partitions as desk dividers at workstations, using dance walls as movable partitions, converting chairs into workstations, increasing the distance between desks and adding more screens 3D (Nediari et al., 2021).

c. Methods

This experimental research uses a website-based eye tracker called RealEye.io. Respondents use independent webcams via their mobile phones and desktops. The experiment follows five steps. The first step is to determine the stimuli to be tested in the experiment. Stimuli based on several office space design references during the pandemic The second step is preparing test material for the website. The third step is collecting data, which is done by providing stimuli and questionnaires to explore perceptions of the design. The fourth stage analyzes the results. The analysis is done in two steps: 1) identify the area of interest based on the respondent's longest duration (fixation), and 2) identify the area of interest based on the respondent's longest duration

(fixation). The results of the self-report were then processed with SEM-PLS to see the correlation between fixation data and questionnaire data. The fifth stage concludes the results of the statistical analysis.

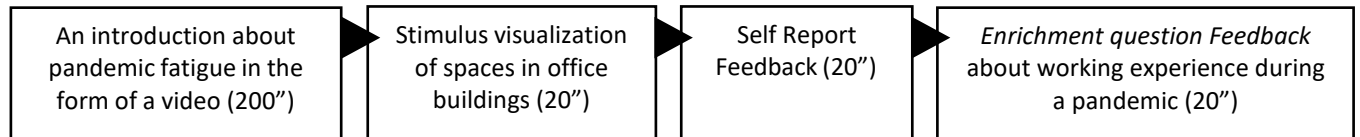


Figure 1 : data collection scheme in giving stimuli

During the experiment, respondents observed ten stimuli for 20 seconds to get the perception described in Figure 1 above. Meanwhile, secondary data relied on their unconsciousness in terms of the number of fixations (NF), the duration of fixation (DF), and the identification of dominant objects seen using fixation position points in pixels (PPI). In the RealEye.io application, fixation coordinates represent the percentage of items displayed, so in the final stage, Adobe Photoshop is used to identify objects with maximum NF and DF points.

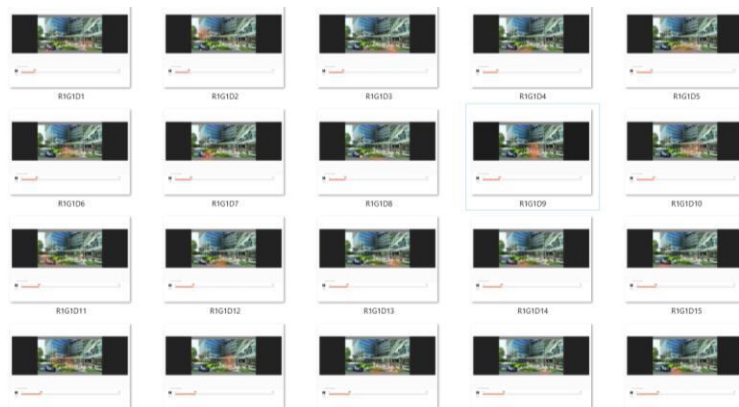


Figure 2: The Fixation Data Recording ETB by using Realeye.io

ETB and SRB data were processed statistically inferentially using SEM (Structural Equation Modeling) and Smart PLS to find a correlation between visual perception and office design criteria. Workplace design recommendations can be developed in response to the problem of pandemic fatigue.

d. Data And Variables

Data was collected from 50 respondents selected from 144.01 million workers in Indonesia based on the CSA (Central Statistics Agency) using the Slovin calculation technique, which has a 15%

margin of error. These numbers were determined based on the premise that using this eye tracker on ordinary people using the random sampling method carries a fairly high risk of error. Therefore, support is needed to perform the test. Data collection follows ethical procedures set by the university.

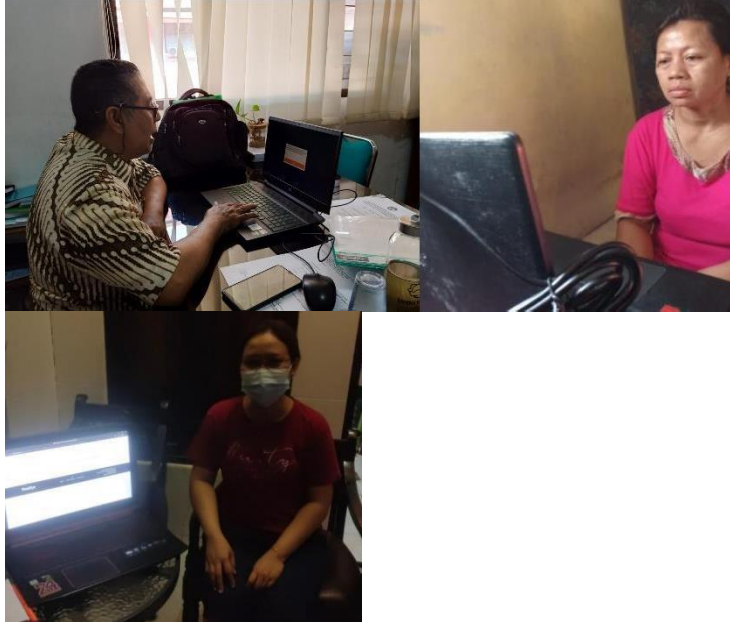


Figure 3: Implementation of the survey on respondents and assistance in ETB.

Result and Discussion

Validity and Reliability Test

Prior to the SEM analysis, the validity of the variable was tested with a stress factor value of >0.5 , which indicated a valid variable. Reliability test using alpha cronbach, average variance extract (AVE), and composite reliability to measure the power of the variables tested. The results of the study show that all variables have an AVE value greater than 0.5, so they can be considered valid. This can also be confirmed by a combined confidence score for all variables > 0.7 , making the variable reliable for further testing.

Table 1: Covariance matrix identified through the SRMR value in the statistical data processing

	Saturated Model	Estimated Model
SRMR	0.085	0.085
d_ ULS	7.427	7.427
d_ G	n/a	n/a
Chi-Square	Infinite	infinite
NFI	n/a	n/a

RMR and SRMR values are obtained from the square root of the difference in the covariance matrix of the sample residual with the hypothesized model. SRMR values range from 0 to 1, with a model fit of less than 0.05 (Byrne, 1998; Diamantopoulos & Siguaaw, 2000). Grades of 0.08 and above are also considered acceptable (Hu and Bentler, undated). All hypotheses were validated with reference to the saturated SRMR and d_ULS model values of 0.085 and 7.427, respectively.

A bootstrap test is performed to confirm the existence of the variable. This test is known as a hypothesis test and can be measured using the t statistic and the p value. In addition, the t-statistic determines the level of significance in hypothesis testing by finding its value through the bootstrapping method. The value obtained must be greater than 0.196. The P-value is an indicator of the simultaneous effect on the variable, and if it displays less than 0.05, the hypothesis is accepted.

Table 2 : Bootstrapping and Statistical tests to determine the correlation between the variables formulated in the three hypotheses.

	Original sample (o)	Sample mean (m)	Standard deviation (stdev)	T statistics (o/stdev)	P values	Conclusion
H1	1.136	1.133	0.074	15.25	0	Accepted
H2	0.842	0.847	0.044	19.155	0	Accepted
H3	-0.2	-0.195	0.093	2.161	0.031	Accepted

The hypothesis test shows that each variable has a direct effect, except fatigue due to the pandemic and office space design. The relationship between the two cannot be confirmed because the P-value is greater than 0.5 and the T-statistic is less than 0.196. Therefore, the problem of fatigue due to the pandemic cannot be directly correlated with office space design. In general, pandemic-related fatigue is caused by internal and external factors that influence a person's decision-making behavior. Capturing or recognizing information received through the five senses requires a certain level of perception. This study examines the perceptions generated by a person's behavior through images or the sense of sight.

The process of perceptual formulation begins when there are environmental cues and ends when individuals become aware of and respond to their presence (Goldstein & Cacciamani, 2022). Stimuli send information to receptors, followed by neural processing, where the individual perceives it in the brain as new knowledge.

Behavior begins with perceptions that are formulated when a person is stimulated. In addition, efforts are made to recognize individual stimuli and actions in response to the results obtained. The issue of fatigue due to the pandemic does not directly correlate with the visualization of office space design, and perception is needed to recognize it.

Table 3: The data elaboration of ETB

Variable	NF	DF (ms)	Loading Factor Value	P values	Object Identification (PPI)
MR	10	12,854	0.96	0	Chair –Table
IWS	11	10,177	0.96	0.001	Block Shape
CWS	13	9,620	0.953	0	Table-chairs
AC	13	8,155	0.933	0.001	Circulation Path
AD	3	2,785	0.932	0	Indoor Activities
SA	10	9,051	0.926	0.001	Field Area
E	15	11,338	0.917	0	Space Divider
L	14	12,854	0.913	0	Service Table
LO	10	8,974	0.894	0	Floor Ornament
UVR	18	13,623	0.781	0	Robot

Note: Meeting Room (MR), Individual Working Space (IWS), Collaborative Working Space (CWS), Activity Circulation (AC), Administration Room (AD), Sport Area (SA), Entrance (E), Lobby (L), Latest Design Office in Indonesia (LO), UV Robot (UVR)

After finding the highest NF and DF in the raw data, object identification is carried out. The percentage of PPI x and y fixation positions were identified using Adobe Photoshop. Table 3 describes the results of QB data processing with loading factors and ETB values with p-value parameters. First, based on the stress factor value of the visual perception variable, the QB results data show that respondents consciously perceive spatial form (0.881), followed by color (0.872), layout (0.849), movement (0.832), dynamics (0.806), space (0.801 and ETB values with p-value parameters. First, based on the stress factor value of the visual perception variable, the QB results data show that respondents consciously perceive spatial form (0.881), followed by color (0.872), layout (0.849), movement (0.832), dynamics (0.806), space (0.801), and finally light (0.769). The last item to be displayed The shape of the building depends on the type of office in Indonesia, namely formal and non-formal. During a pandemic, both are at high risk of transmitting the disease. Therefore, there are only a few designs. Strong reasons why many respondents like certain forms of buildings need to be further investigated in future studies. Second, after the highest QB is identified, the results of the ETB MR are displayed, which are noticed by room users according to their memories of working in the

pandemic era. Testing with an eye tracker to recognize room typology shows that respondents in MR are interested in the arrangement of furniture.

The places that most influence subconscious responses are meeting rooms (MR) and private workspaces (IWS), with the same stress factor score of 0.96. In the meeting room, 10 respondents have a total DF of 12.854 m/s. The dominant objects seen by individuals are tables and chairs. Meanwhile, 11 respondents had a total DF of 10,177 m/s in a private workspace.

Solutions to space design problems to deal with a pandemic are urgently needed. Several previous studies reported that some positive cases were caused by 1) air flow in the room, 2) materials used in the manufacture of furniture, and 3) room cleanliness (Kampf et al., 2020). According to WHO, the most important procedures when conducting meetings in the workplace are furniture cleanliness, the room's ability to avoid direct contact, and adequate air circulation. This leads to semi-open designs or even fully open spaces. The need for a meeting room was then seen as a solution.

The results of the author's research confirm that the most frequently seen objects in the room are tables and chairs. Space triggers the perception of ergonomic design among users who want to ensure their work safety and productivity (Noshin et al., 2018).

Stimulus in the workspace is divided into two types, namely overt (non-isolated) and cubic (isolated), each of which is collaborative and personal (CWS and IWS). The load factor values of the two space intervals are relatively the same. However, in private workspaces, respondents paid the most attention to the partition design itself; several other solutions include using a portable design model that adapts to the environment (Fiorelli, 2017). In the book "Architecture in Motion," different perspectives on cellular life are presented and predicted as patterns of future life (Kronenburg, 2013). Every newer or innovative design results in compact forms, and for collaborative workspaces, respondents are looking for tables and chairs.

The next improvement is the access point at the entrance to the building and activities in the service room. With a total fixation time of 8.155 ms, some respondents observed a wall with doors. The strict regulation of implementing health protocols during a pandemic has resulted in the need for less active blood circulation pathways. The policies implemented change based on the daily rate of COVID-19

cases, starting with the rule that 20%, 50%, 75%, or 100% of workers are allowed to enter the office. This increases restrictions on movement while working during a pandemic. Therefore, respondents paid more attention to indoor pathways and activities related to this stimulus. Respondents feel that circulation needs to be expanded.

The fourth stimulus, the role of the sports room (SA) in office buildings, received a lot of attention from respondents. The entrance and lobby were the initial spark that led to the construction of this office building. During the pandemic, every worker is expected to carry out contact tracing with COVID-19 survivors, so many sources focus on the division. Therefore, the cycle must be designed in such a way that it is not tiring before starting work.

The sixth stimulus relates to current design while applying technology (UVR) to reduce disease transmission in the workplace. The application of indoor technology, such as the use of UV disinfecting robots developed during the pandemic, has influenced the design of office spaces.

This study produces perceptions of workplace design through three perspectives included in the hypothesis: the point of view from the fixation response on the eye tracker to the design; the second is the response through self-report after observing the given design stimulus; and the third is the relationship between the two responses.

The first point of view proves that the fixation of respondents is influenced by objects observed in certain office space designs; the identification of these objects forms the basis of these observations in finalizing designs to deal with a pandemic. These results explain that attention to the meeting room and the use of technology have the longest duration. Open-form workspaces are not suitable for a pandemic. Interior decoration must pay attention to changes in the atmosphere of the room, layout, and selection of materials. The second view is based on the results of self-reports; above, there are twelve feedbacks based on the spatial experience given after the stimulus. What stands out the most about this answer is that a private workspace is the safest place to feel safe. Also, the last angle regarding the perceptual relationship created by fixation and busy cells proves the influence of the two in shaping the design of workspaces during a pandemic.

CONCLUSION

The relationship between pandemic fatigue and visual perception of office space design in the three hypotheses shows a positive correlation. This is evidenced by the p-value 0.05 and t-statistic > 0.196 of the three variables. This research guides design concepts based on working memory during a pandemic, inspired by 10 types of office designs that are suitable for unconditional times such as a pandemic. QB results show that the shape of the office design needs to be adjusted. Meanwhile, the ETB results show 12 recommendations from each of the fields discussed above. Suggestions for changes that can be made to design a post-COVID-19 safe office must prioritize the health of employees. Eye tracker observations show that respondents focus on spaces that trigger personal anxiety because they require direct contact with other people. Meanwhile, the answers to the questions raised are more likely to lead to recommendations for privatization. From this, it can be concluded that the safest space to work during a pandemic is a private workspace.

The limitations of research with eye trackers arise when interpreting your fixation data. The validity of the data from these technologies varies greatly, but when tested statistically, the reliability score reaches 0.99. Therefore, another measurement tool is needed, e.g., self-report, to translate the results of perception so that they can be used as a design reference. Future research on architectural objects with a neuroscientific approach can be deepened with eye tracker technology because the eyes can see expression, emotion, and meaning. This will provide lots of references to look at the experiences of the people in the room.

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COMPETING INTERESTS

The authors have no competing interests to declare.

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