

The design of public services area in a government office building integrating Bayesian Brain Perceptual Mapping

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Abstract: The Bayesian Brain Behavioural Mapping framework examines how multisensory stimuli affect worker perception and the mitigation of fatigue within workspace environments, particularly during the COVID-19 pandemic. TPDK Disdukcapil Semarang was selected as a case study due to its notable digital service innovation during the pandemic, which enabled remote access to essential public administration services. This innovation ensured continuity of service, improved public accessibility, and received national recognition for its effectiveness. This study employed an observational case study approach combined with real-time electroencephalogram (EEG) monitoring to examine how a fatigued worker experienced their workspace. A portable EEG device recorded the participant's brainwave activity as they performed routine administrative tasks. The EEG data captured cognitive and emotional responses to multisensory environmental stimuli, including visual (lighting and colours), auditory (coughing and sneezing), and olfactory (disinfectant smells) inputs that were prevalent during the pandemic. The researchers assessed worker fatigue using a triangulated method that combined self-reported data and behavioural observation. The Fatigue Assessment Scale (FAS) was used to evaluate physical and mental fatigue. Observable indicators such as reduced focus, slower movements, and facial expressions helped validate the subjective reports. This research applies Bayes' Theorem to model how seven environmental factors, such as contrast, atmosphere, context, dimensions, space density, emotional tone, and spatial originality, can influence perceived comfort and the likelihood of spatial persistence. The findings highlight that neurocognitive elements, such as density, atmosphere, contextual fit, and emotional stability, are critical in shaping the spatial experience. For instance, lower density and emotional stability were associated with greater comfort in administrative spaces, while a sense of originality was essential in archive areas. By integrating Bayesian analysis with spatial design, this study provides a framework for architects to create work environments that align with human cognitive and emotional responses, promoting resilience and well-being, particularly in response to pandemic-related challenges.

Keywords: Bayesian brain perceptual mapping; Workspace design; Multisensory stimulus; Pandemic; Government offices.

1.0 INTRODUCTION

Workspace design has increasingly prioritised users' psychological and behavioural needs. The brain responds to environmental stimuli in ways that shape human behaviour, and neuroscience provides valuable insights into how perception drives emotional and cognitive reactions. Effectively perceiving our surroundings makes sensory experiences more meaningful and relevant, helping individuals adapt and perform better. The COVID-19 pandemic introduced new and unusual stimuli into the workplace, such as increased coughing and sneezing sounds, strong disinfectant smells, and altered lighting or colour schemes. Researchers have demonstrated that these changes impact workers' cognitive focus, emotional regulation, and physical stamina, leading to what is now commonly described as pandemic fatigue.

Our brains respond to stimuli through multisensory and dynamic processing, and Bayesian analysis helps us understand how perceptions shift when exposed to novel stimuli. This research employs Bayesian brain-behavioural mapping, a neuroscience-based approach grounded in Bayes' Theorem, to know how the brain processes and adapts to such multisensory changes. This theory suggests that the brain continuously makes predictions based on prior experience and updates them when exposed to new sensory information. Applied to architecture, this understanding enables designers to comprehend how users cognitively adapt to environmental changes, particularly under stress or fatigue.

This study examines how sensory experiences, particularly lighting, colour, spatial layout, and ambient stimuli, influence the perception of comfort and persistence in the workspace. Researchers have identified these elements as key factors influencing brain responses and fatigue levels, particularly in high-demand environments such as government service offices. We selected the TPDK Disdukcapil office in Semarang as a case study because of its nationally recognised digital service innovations during the COVID-19 pandemic. It implemented a remote-access system that allowed citizens to obtain services online, ensuring continuity during lockdown periods. However, this innovation also introduced new operational demands for staff, increasing their workload and fatigue.

Additionally, the spatial layout of the office reflects standardised government design, making it a relevant example for broader public sector environments across Indonesia.

Despite increasing interest in neuroarchitecture, few studies have investigated the interaction between cognitive fatigue and environmental perception in public service settings (Zhang *et al.*, 2019; Arinta *et al.*, 2024). This research bridges that gap by applying EEG-based brain mapping to assess real-time brainwave responses under different spatial and sensory conditions. The study contributes theoretically by presenting a model that demonstrates how Bayesian principles can inform workspace design to enhance cognitive resilience and comfort during disruptive conditions, such as a pandemic. By integrating neuroscience and architectural design, this study aims to inform future workspace planning that better supports employee well-being in dynamic and stimulus-rich environments.

2.0 THEORETICAL FRAMEWORK

2.1 The Bayesian Brain Theory

The brain never processes information from just one sense at a time. Neuroscience provides a theoretical foundation that accurately recognises the sensory elements present in space for shaping spatial experiences (Goldstein & Cacciamani, 2022). Bayesian Brain Theory refers to a cognitive neuroscience concept where the brain functions as a prediction machine, continuously generating hypotheses about the world and updating them based on sensory input. This model offers a framework for understanding how the brain forms perception and how spatial environments influence it. Perception formation arises from the information gathered by our sensory systems, which is then processed into recognition, often used to assess comfort within a space. The way of how an individual perceives their environment, results from a multisensory integration of their sensory systems (Spence, 2020).

This research posits that perceptions of space are closely linked to the likelihood of experiencing work-related fatigue. Previous studies have identified seven factors that influence the formation of these experiences: contrast, atmosphere, context,

dimensions, space density, emotions, and originality of the space ([Arinta et al., 2024](#)). By adapting Bayes' Theorem to estimate these perceptions, the study reinforces the significance of these factors in shaping the experiences created, enabling individuals to endure their fatigue. Pallasmaa previously articulated the concept of resilience in this context, suggesting that architecture is an art of reconciliation that engages the entire sensory system ([Pallasmaa et al., 2017](#)). This perspective underscores the intricate relationship between our sensory experiences and our capacity to navigate the challenges presented by our environment.

The Bayesian Brain Theory, originating in cognitive neuroscience research, suggests that human minds do more than react to external stimuli; they interpret them and gain deeper insights into our world. Reports indicate that our brains make predictions using Bayes' principles ([Friston, 2005](#)). Bayes's Theorem provides the mathematical structure that enables the brain to modify perceptions based on new sensory data ([Friston, 2005](#)). The brain first absorbs all sensory input. It compares this data to prior expectations and detects any mismatches, known as prediction errors. These errors help refine future perceptions and responses. Any discrepancies between predictions and actual outcomes are known as prediction errors, which prompt changes in perception, thus improving the precision of perception processes and reactions to environments. Mathematically, the basic formula of the Bayesian theory is:

$$P(H|E) = \frac{P(E|H) \cdot P(H)}{P(E)}$$

Information:

- $P(H|E)$ = The probability of hypothesis H being correct after the presence of evidence E (also called posterior).
- $P(H)$ = The initial probability of hypothesis H before there is new evidence (also called a prior).
- $P(E|H)$ = The probability of receiving proof E if hypothesis H is true (also called likelihood).
- $P(E)$ = The probability of receiving evidence E, regardless of hypothesis H (also called marginal likelihood or evidence).

In the Bayesian brain, hypothesis H represents various assumptions or predictions made by the brain; evidence E is the sensory data it receives (such as vision, hearing, or touch). The brain uses prior information and updates its beliefs based on new sensory data. The human brain never processes information from just one sense at a time. Instead, sensory information from various modalities (such as vision, hearing, touch, and smell) is

integrated simultaneously to accurately represent the environment. The human brain uses Bayesian inference to process sensory data, make predictions, and direct actions by continuously updating its beliefs based on past experiences and new evidence. Bayesian inference enables the brain to update its beliefs in response to new sensory data. Before presenting the mathematical formula, it is essential to understand how this logic underpins perception in uncertain or changing environments. In neuroscience, this theory describes how the brain integrates prior knowledge and sensory feedback to optimise perception, motor control, and decision-making in uncertain situations ([Körding & Wolpert, 2004](#); [Pouget et al., 2013](#)). This concept is also applied to artificial neural networks, which improve prediction accuracy by integrating uncertainty ([Zhang, 2019](#)). The brain employs Bayesian inference to resolve ambiguities in visual perception ([Kersten et al., 2004](#)), and neural dynamics can be understood as a stochastic sampling process that facilitates Bayesian computation ([Buesing et al., 2011](#)).

The application of this theory extends to various fields, including artificial intelligence and machine learning, which utilise Bayesian models to improve adaptive and robust decision-making ([Kristiadi et al., 2022](#); [Sagar, 2020](#)). This research uses the theory to analyse patterns of multisensory integration behaviour in brain area performance using Bayesian principles to create a unified prediction of perception in space.

2.2 Multisensory stimulus in spatial design exploration

In spatial design, this theory explains how people process and adapt to multisensory environments, lighting, colour, sound, and smell based on prior experiences and real-time input. The experience makes Bayesian analysis a helpful tool for understanding how spatial stimuli affect perception and fatigue in workspaces. Recent office design has increasingly focused on multisensory aspects to create an environment conducive to users. Multisensory stimuli involve various senses, such as vision (lighting, colour), hearing (sound or noise), smell (aroma), and touch (texture or material). The physical environment is designed with these multisensory elements to influence emotions, behaviour, and cognitive performance ([Goldhagen, 2019](#)). The concept of multisensory design recognises that human experiences engage multiple senses, and by combining sensory stimuli like sound, lighting, and aroma, we can enhance emotional, cognitive, and physical responses to the environment ([Imschloß & Kuehn, 2017](#)). In retail environments,

aligning music with other elements, such as flooring, can improve the shopping experience. In recent years, healthcare design plays a critical role in shaping user experience. For instance, rooms that are purposefully designed to stimulate the senses of older adults can improve cognitive function and motor skills ([Cavanagh et al., 2020](#); [Mendrofa, 2023](#)). Beyond clinical environments, healthcare design also contributes to the creation of inclusive public spaces that foster empathy and social engagement ([Rieger & Chamorro-Koc, 2022](#)). Multisensory learning environments can enhance student engagement and memory retention in education, particularly in subjects such as Mathematics ([Cuturi et al., 2021](#); [Kwon & Iedema, 2022](#)).

On an urban scale, integrating sensory elements such as thermal comfort and physical experience can enhance pedestrian satisfaction ([Degen & Rose, 2012](#); [Vasilikou & Nikolopoulou, 2019](#)). Ultimately, incorporating elements such as touch, taste, and smell into human-computer interaction systems can enhance user engagement and create a more immersive experience ([Obrist et al., 2017](#)). Some studies have filled the research gap in connecting neuroscience with workers' spatial experiences in administrative service contexts, such as those found in the Disdukcapil office. From this theoretical framework, we can understand how multisensory elements influence worker behaviour and mental health. Therefore, designing work environments that are more adaptive and responsive to complex and unpredictable stimuli, especially in the post-pandemic era, will be an essential recommendation.

2.3 Behavioural mapping and Neuroscience in workspace design

Behavioural mapping is a method for tracking how people behave in a specific environment. It is commonly used in architecture and space planning to see how users interact with physical spaces. In a workplace, behavioural mapping reveals how space design influences worker behaviours, such as movement patterns, facility usage, and the tendency to gravitate toward specific areas. When combined with the Bayesian Brain approach, Behavioural Mapping goes beyond just observing physical behaviour. It also looks at how the brain processes stimuli from the environment. Our brains naturally combine sensory inputs, such as sight, sound, and smell, to create a complete experience of a space. By using brain-based behavioural mapping, designers can better understand how to optimise workspaces based on how the brain responds, both cognitively and emotionally ([Spence & Deroy, 2013](#)). This process is tied to active inference,

where the brain adjusts its perceptions and behaviours based on environmental feedback ([Clark, 2013](#)). Active inference is the brain's mechanism for minimising prediction errors by taking actions or adjusting perceptions. In workplace design, this implies that people continuously reshape their mental models of space in response to changing stimuli—like adjusting to dim lighting or filtering out background noise—affecting how long they can remain productive in that environment. In the workplace, workers are constantly, even subconsciously, reassessing and updating their perception of the space around them based on changes like temperature, lighting, or noise levels.

In this study, neuroscience is the foundation for mapping the connection between environmental stimuli and changes in worker behaviour. This information makes workspace designs more responsive to users' needs. Tools like EEG allow researchers to measure brain activity directly. At the same time, workers engage with the space, providing designers with data to evaluate how lighting, colour, and noise impact worker performance and overall well-being.

Beyond EEG, other neuroscience tools such as eye-tracking, functional magnetic resonance imaging (fMRI), and skin conductance sensors offer complementary ways to analyse how workers interact with their environments. These methods can capture attention shifts, emotional arousal, and brain activity patterns relevant to spatial experience. Applying the Bayesian Brain Theory and behavioural mapping enables architects to predict how workers respond to sensory environments and design spaces that minimise cognitive load and maximise emotional comfort. These insights support evidence-based design strategies to improve well-being and productivity.

3.0 MATERIALS AND METHODS

This study investigates case studies using an observational approach, integrating EEG instruments and Virtual Reality (VR) technology for data collection. The focus is on TPDK Disdukcapil, located in Semarang, where the government office buildings experienced the highest transmission rates during the pandemic (**Figure 1**). Given the large number of COVID-19-related fatalities, the office could not be entirely transitioned to online services, providing a unique context for studying worker adaptation to pandemic-related stimuli while under risk of exhaustion. These offices offer insights into how the brain adjusts to these stressors, and Bayes' Theorem is used to predict perception changes based on the workers' brain performance. The choice of TPDK

Disdukcapil as the study setting is due to the unique challenges public service workers face during the pandemic. The office environment remained operational despite the high transmission rates in the area. As such, the study provides a valuable case to explore how workers cope with physical and cognitive

stressors, especially given their direct contact with the public. Additionally, the office space was modified during the pandemic, adding partitions to protect against viral transmission. It is an interesting setting to study the interplay of environmental changes and their neurocognitive effects.



Figure 1: Type of public service area observed. The researchers categorised the 16 existing workstation desk designs during the pandemic into four types: **(1)** workstations separated by desks across 3-4 areas, **(2)** workstations without desk separations across 3-4 areas, **(3)** workstations without desk separations across two areas, and **(4)** workstations separated by desks across two areas.

The study utilised a wireless EEG system, EMOTIV EPOCX, which is designed for general research purposes and not for clinical diagnosis. The EEG data collection was integrated with VR technology to enhance spatial and sensory data gathering. The VR headset, Oculus Quest 2, was connected to two computers to record EEG data and provide visual stimuli via the VR system. As illustrated in **Figure 2**, the experimental setup presented stimuli to workers with prior experiences of pandemic-related fatigue, including visual, auditory, and olfactory inputs. These stimuli were administered in stages, progressing from single-sensory to multisensory conditions. This integration enabled a controlled multisensory environment to investigate its impact on worker fatigue and cognitive responses.

The study employed a census method to select the sample, given the relatively small population of workers at the TPDK Disdukcapil office. All workers were initially included in a field observation survey to gather general data. From this pool, ten individuals were selected for detailed study and chosen to represent a balanced

demographic from four districts: Gayamsari, Candisari, Tembalang, and Semarang Barat, with two to three workers from each district. The selection aimed to ensure a diverse representation of age, gender, and work experience. The study assessed worker fatigue using the Fatigue Assessment Scale (FAS). FAS scores above 34 indicate moderate to severe fatigue, which suggests that a significant portion of workers in this setting are experiencing fatigue-related health risks. The researchers analysed the workers' demographics and revealed that they were between 20 and 30 years old, with a near-equal gender distribution and varied educational backgrounds. The survey results indicated that 70% of workers reported significant fatigue, with many exhibiting scores that align with moderate to severe fatigue. According to Michielsen et al. (2003), a FAS score above 34 indicates moderate to severe fatigue, suggesting a high prevalence of fatigue-related risks among workers in this environment. This finding highlights the pandemic's impact on their health and well-being, as well as their productivity.

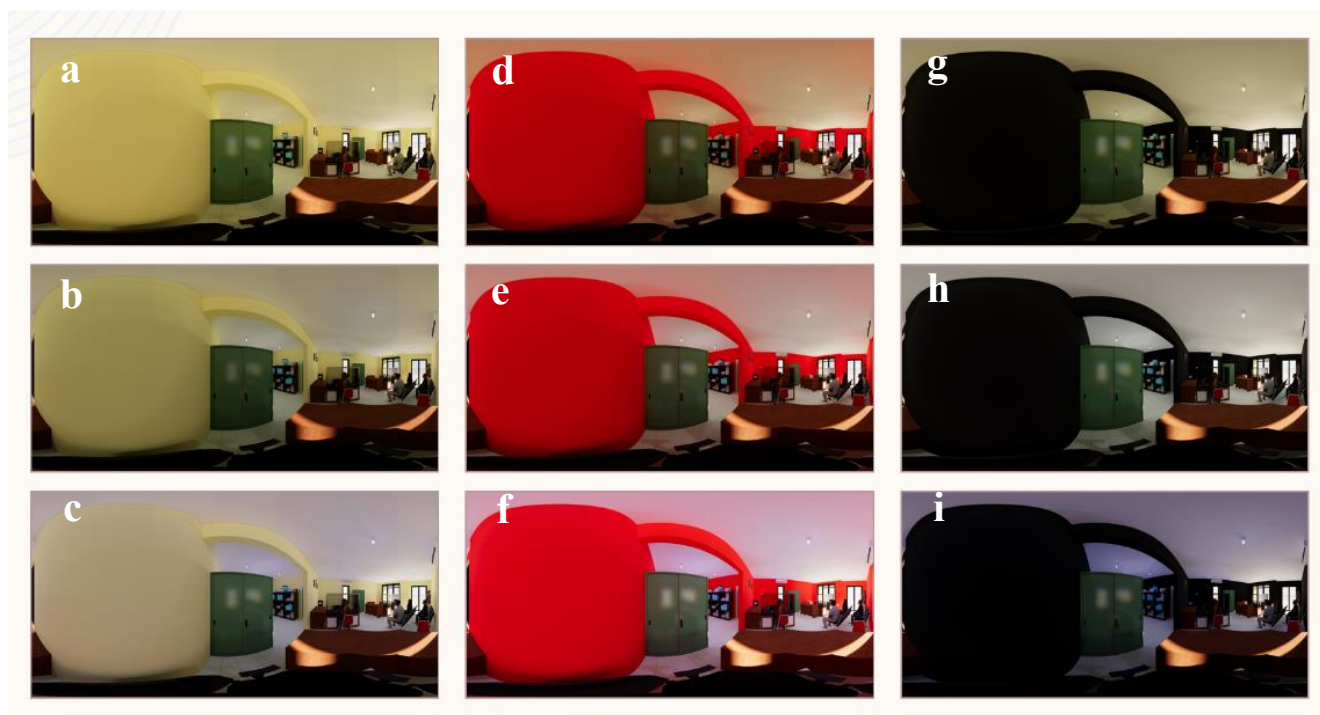


Figure 2: Visualisation of visual stimuli. (a) O.L.1 with warm white light; (b) O.L.2 origin with white light; (c) O.L.2 white light; (d) red R.L.1 with warm white light; (e) red R.L.2 with white light; (f) red R.L.3 with cool white light; (g) black B.L.1 with warm white light; (h) B.L.2 black with white light; (i) black B.L.3 with cool white light. The abbreviations “O.L.” (original lamp), “R.L.” (red lamp), and “B.L.” (black lamp) denote the lamp categories used to define variations in visual stimulation. These variations were designed to direct perceptual responses in different ways, allowing the study to map cognitive tendencies and estimate the likelihood of particular perceptual orientations under different lighting conditions.

4.0 RESULTS AND DISCUSSION

This research calculates the likelihood of a person enduring in a space with stimuli and sensory disturbances. It does this by identifying the factors that influence the probability of endurance, referred to as $P(B)$, which is affected by environmental stimuli and visual dimensions. The primary focus is on measuring the stimulus $P(E)$, which relates to a person's ability to accurately recognise the stimuli $P(E|H)$ and the probability of experiencing low sensory disturbances $[1-P(H|E)]$.

The first factor in measuring is a person's fundamental ability to recognise stimuli effectively, even when there are sensory disturbances. If everyone can recognise the stimuli without any issues, this ability does not limit the application of the formula, allowing us to assume $P(E|H)=1$. The second factor is the extent of sensory disturbance that occurs in that space. If sensory disturbances are low or $P(H|E)$ is small, then the $1-P(H|E)$ becomes high, increasing the chances of endurance. The assumption is that the recognition ability, $P(E|H)$, does not depend on whether sensory disturbances, $1-P(H|E)$, occur or not. Therefore, we can calculate the probability of endurance by multiplying these two probabilities using the formula:

$$PB = P(E|H) \cdot (1 - P(H|E))$$

By assuming that the ability to recognise stimuli accurately is $P(E|H)$, we can interpret the probability of recognising stimuli correctly despite sensory disturbances as the individual's cognitive ability to cope with those disturbances. If this value is 1.0 (100%), it means that sensory disturbances do not affect the ability to recognise stimuli, indicating that the impact of sensory disturbances is minimal. The probability of no sensory disturbances occurring while a person is in the space illustrates an environment that supports individual cognition. The value of 1 in this formula comes from the maximum probability value in probability theory, which indicates certainty (100%). We use this value of 1 as the basis for the complement of the probability $[1-P(H|E)]$, which measures the likelihood of the complementary event (no sensory disturbances). The combination of these two probabilities provides insight into the likelihood of a person being able to endure in that environment.

This formula helps to assess how multisensory stimuli shape user experiences in workspaces. It also provides insights into pandemic fatigue from an architectural perspective, influencing perceptions of workspace

function and comfort. The leading theory by Juhani Pallasmaa suggests that architecture plays a crucial role in human engagement, enabling individuals to endure in their environments ([Pallasmaa et al., 2017](#)). These perspectives become an art of adaptation from one place by involving sensory functions. This research examines the pandemic phenomenon, framing the work experience as a survival experience under certain conditions, particularly the fatigue experienced during the pandemic.

Next, we applied the formula to the results of case groupings of spaces and their relation to the seven aspects identified. We assigned numerical codes to the dominant and interrelated stimuli of these seven aspects. $P(E)$ represents the percentage of stimuli affecting endurance. It is calculated by dividing the number of influencing stimuli by the total number of stimuli (15), then multiplying by 100%. The calculation of $P(H)$ serves as an indicator of sensory disturbances. It is obtained by calculating the percentage of sensory inputs involved in influencing the stimuli compared to the total sensory inputs tested (light, colour, sound, and smell), and then multiplying by 100%. Subsequently, $P(E|H)$ represents an individual's cognitive ability to recognise the space, which is assumed to have four graded levels to explain this mental condition.

Level 1: 100%, indicating that a person can accurately recognise the space. The initial response to the originality of the space reveals these numbers. If the response is detailed and precise, the worker recognises it well. **Level 2:** 50%, assigned if the worker recognises the space hesitantly, meaning they can only identify the space at 50%. **Level 3:** 25%, given if the recognition is biased or inaccurate. **Level 4:** 0%, assigned when the worker cannot recognise the space.

After the three elements have been assigned values, these values are input into the basic formula of Bayes' Theorem to find the value of $P(H|E)$, which indicates the probability of sensory disturbances resulting from the stimuli in the space. Once we obtain this value, we calculate the likelihood of endurance, $P(B)$, using only two components: the probability of sensory disturbances, $P(H|E)$, and the probability of cognitive ability, $P(E|H)$, in recognising the space due to the stimuli provided. This formula multiplies both probabilities together. However, before this multiplication, the value of $P(H|E)$ is modified to $[1-P(H|E)]$. We make this adjustment because we assume that the given probability represents the magnitude of the existing sensory disturbances and the

likelihood that these disturbances are insignificant. Therefore, the result of this subtraction defines the formula. P(B) results are then visualised in a table, using green to indicate higher values and red for lower values. This colour coding helps to easily identify the levels of endurance based on the calculated probabilities.

As shown in **Table 1**, the endurance probability for spatial aspects such as originality, contrast, and contextuality in the administrative service area reached 73% under complete recognition levels [P(E|H) = 100%]. The result suggests that workers can recognise these elements effectively, even amidst sensory disturbances. On the other hand, the atmosphere showed a slightly lower endurance at 67%, suggesting room for improvement in how this element is perceived cognitively. The highest probabilities were recorded for spatial density and emotions, each at 87%, reflecting their dominant role in shaping comfort and persistence in public-facing spaces. The survival probabilities of individuals in the public administration area indicate significant variations in recognition levels across different categories. The overall endurance level is 73% for full recognition capacity, which decreases to 43% at

moderate recognition and further drops to 23% at low recognition levels. Notably, the lowest recognition level is 0% for those unable to recognise the space.

When examining specific aspects, contrast recognition mirrors the originality of the space, maintaining a 73% endurance level at maximum capacity, with similar declines at lower recognition levels. Contextual recognition follows the same trend, while the ability to recognise the atmosphere is slightly lower, starting at 67% at full capacity and decreasing to 42% at moderate recognition.

Spatial density and emotional recognition are the most easily identifiable categories. Both achieve an impressive 87% recognition at maximum capacity, though they also experience lower-level declines. The gradual decrease in recognition across all categories suggests that while each aspect contributes to the user experience, its influence varies. The atmosphere, in particular, shows potential for improvement, as it currently has the lowest recognition rate. Enhancing this aspect could significantly enrich the user experience in the public administrative service area.

Table 1: Application of probability formula to findings in case of administrative service area

Public Administrative Service Area	P(E) Number of Stimulant	P(H) Number of Sensory Inputs Tested	P(H E) Probability of sensory response occurring with a stimulus.	P(E H) An individual's cognitive ability to recognise space.			
				100%	50%	25%	0%
Originality	7%	25%	27%	73%	43%	23%	0%
Contrast	13%	50%	27%	73%	43%	23%	0%
Contextuality	20%	75%	27%	73%	43%	23%	0%
Atmosphere	33%	100%	33%	67%	42%	23%	0%
Spatial Dimension	13%	50%	27%	73%	43%	23%	0%
Spatial Density	7%	50%	13%	87%	47%	24%	0%
Emotion	13%	100%	13%	87%	47%	24%	0%

Green = higher values; Red = lower values

Findings from the data recording room (**Table 2**) reveal that spatial density and emotional recognition have endurance probabilities of 91%, suggesting that these aspects are critical for supporting concentration and sustained cognitive performance. Meanwhile, originality maintains a solid endurance rate of 73%, while contextuality and contrast drop to 47% and 64%, respectively, under full recognition. These results emphasise the need for better spatial cues to support

contextual understanding and visual clarity. The findings reveal that the probability of recognising the originality of the space is 73% at the highest cognitive level, but this drops significantly to 43% at a moderate level and further to 23% at a low level. This result indicates that maintaining a sense of originality requires considerable cognitive effort, especially in challenging environments.

Contrast recognition shows a probability of 64% at full cognitive capacity, decreasing to 41% and then 23% at lower levels, suggesting that while contrast is still recognisable, it becomes more difficult under sensory stress. On the other hand, contextuality has a lower endurance probability, starting at 47% and falling to 22%, indicating that recognising the context of the space is particularly challenging in high-disturbance situations.

The atmosphere of the room is perceived strongly, with an endurance probability of 80% at full cognitive capacity, but this also declines to 45% and 24% at lower levels. Spatial dimensions maintain a 73% recognition

rate at maximum cognitive ability, while spatial density and emotional recognition stand out with the % endurance probabilities of 91%. These elements remain easily recognisable even in the presence of sensory disturbances.

Collectively, results from the data recording area suggest that spatial density and emotional recognition are crucial for enhancing an individual's endurance in the data recording room. In contrast, contextuality and contrast require more attention in design to improve user experience. These insights are essential for optimising the space to support worker performance and comfort better.

Table 2: Application of probability formula to findings in the case of data recording room

Data Recording Room	P(E) Number of stimulant	P(H) Number of sensory inputs tested	P(H E) Probability of sensory response occurring with a stimulus.	P(E H) An individual's cognitive ability to recognise space.			
				100%	50%	25%	0%
Originality	7%	25%	27%	73%	43%	23%	0%
Contrast	27%	75%	36%	64%	41%	23%	0%
Contextuality	27%	50%	53%	47%	37%	22%	0%
Atmosphere	20%	100%	20%	80%	45%	24%	0%
Spatial Dimension	13%	50%	27%	73%	43%	23%	0%
Spatial Density	7%	75%	9%	91%	48%	24%	0%
Emotion	7%	75%	9%	91%	48%	24%	0%

Green = higher values; Red = lower values

Furthermore, the archive room presented the lowest endurance scores among all spaces (Table 3). Notably, atmosphere scored 0% across all recognition levels, indicating a complete lack of perceptual support in this category. The endurance probability for contrast also declined sharply, from 25% to 0%, showing significant difficulty in visually processing the space. Only spatial dimensions and originality reached 50% and 75% recognition levels, but even these showed rapid degradation under lower cognitive conditions. These findings underscore the static and less stimulating nature of archive spaces, which require design interventions to enhance emotional and mental support. Contextuality fares are slightly better, achieving 50% recognition at the highest cognitive level, but then decreasing to 25%, 13%, and finally 0% at the lowest level. The result suggests that recognising the context of the space is particularly challenging. The

atmosphere is a significant concern, as it shows a 0% endurance probability across all cognitive levels, indicating that workers do not recognise or feel this element.

Regarding spatial dimensions, the endurance probability is 50% at the highest cognitive level, which is relatively strong, but it declines to 25%, 13%, and ultimately 0% at lower levels. It indicates that while spatial perception is essential, it diminishes significantly under high-disturbance conditions. Spatial density and emotional recognition follow a similar pattern, starting at 25% at the highest cognitive level and dropping to 0% at the lowest. This result shows that emotional elements do not significantly enhance workers' endurance in the archive room. The findings indicate that spatial originality and dimensions are the most recognisable elements, although they still experience

significant declines under sensory disturbances. In contrast, the atmosphere and contrast require urgent improvement, as they currently do not effectively support workers' endurance. These insights highlight the need for optimisation in the archive room to enhance workers' overall experience and resilience.

Collectively, these results suggest that high-functionality spaces, such as the administrative service area and the data recording room, foster better endurance against sensory stimuli. These environments support work interactions, allowing workers to adapt

more easily. In contrast, with its lower functionality and static atmosphere, the archive room shows lower endurance probabilities, particularly in emotional and atmospheric elements. This finding highlights the need for design improvements that enhance cognitive engagement and promote well-being. Conversely, the archive room, characterised by lower functionality and a more static atmosphere, exhibits lower endurance probabilities in elements such as emotions and atmosphere. It reflects a lack of interactive or dynamic elements that could enhance cognitive experiences.

Table 3: Application of probability formula to findings in cases of the archive room

Archive Room	P(E) Number of stimulant	P(H) Number of sensory inputs tested	P(H E) Probability of sensory response occurring with a stimulus.	P(E H) An individual's cognitive ability to recognise space.			
				100%	50%	25%	0%
Originality	7%	25%	25%	75%	38%	19%	0%
Contrast	7%	25%	75%	25%	13%	6%	0%
Contextuality	20%	100%	50%	50%	25%	13%	0%
Atmosphere	13%	50%	100%	0%	0%	0%	0%
Spatial Dimension	13%	50%	50%	50%	25%	13%	0%
Spatial Density	7%	75%	75%	25%	13%	6%	0%
Emotion	33%	100%	75%	25%	13%	6%	0%

Green = higher values; Red = lower values

The findings highlight the need to optimise design elements to improve the work experience, particularly in static or passive spaces. **Figure 3** illustrates how design components adapt to the functional and cognitive needs of workers across three workspaces: the public administrative service area, the data recording room, and the archive room. Dynamic spaces, such as the data recording room and public administrative service area, provide greater support for worker adaptation, whereas the archive room requires improvements in atmosphere and emotional interaction.

As shown in **Figure 3**, the public administrative service area and the data recording room share a high overlap in emotional and contextual elements, indicating that workers in these areas benefit more from adaptable and emotionally supportive environments. In contrast, the archive room shows the fewest overlapping elements

and the lowest endurance probability, underscoring the need for spatial and atmospheric improvement.

Table 3 further reveals that spatial density and originality consistently contribute to worker endurance across all three spaces, while contrast becomes uniquely important in the archive room due to its role in document differentiation and order.

Overall, the public administrative service area emphasises emotional atmosphere and spatial coordination, fostering supportive and collaborative environments. The data recording room integrates elements that facilitate cognitive engagement and adaptability, enabling workers to process information efficiently while minimising distractions. Meanwhile, the archive room, with its static and less interactive qualities, requires optimisation, particularly in its emotional and atmospheric aspects, to improve worker endurance and overall experience. This visualisation

demonstrates how different components interact in each workspace, emphasising the importance of thoughtful design in fostering productive and supportive work environments.

Certain elements are crucial in shaping optimal work experiences in workspace design. Research has shown that specific elements within a space significantly enhance the brain's cognitive functions, as highlighted by Zhang et al. (2024). This understanding leads us to explore the dynamic nature of various work environments, particularly in areas such as administrative services and data recording. In dynamic spaces such as data recording, several elements intersect to create a universal overlap, with space density and emotional factors emerging as the most influential. This overlap reflects a remarkable degree of flexibility and adaptability, essential for fostering productivity. Space density and emotional factors

support intensive work activities and help employees perform tasks efficiently. A well-organised and emotionally supportive atmosphere is vital, especially in spaces like data recording, where comfort is paramount for maintaining focus and attention during administrative tasks.

However, the narrative shifts when we consider more static environments, such as the archive room. In these spaces, elements partially overlap because they support specific technical functions. The Archives exhibit a high level of sensory disturbance, which requires maintaining conditions that promote work efficiency. Unlike dynamic spaces, the Archives require fewer universal elements that provide flexibility or adaptability. The atmospheric element plays a minimal role here; the primary focus is on storage functions and technical order, with no need for emotional comfort or human interaction.

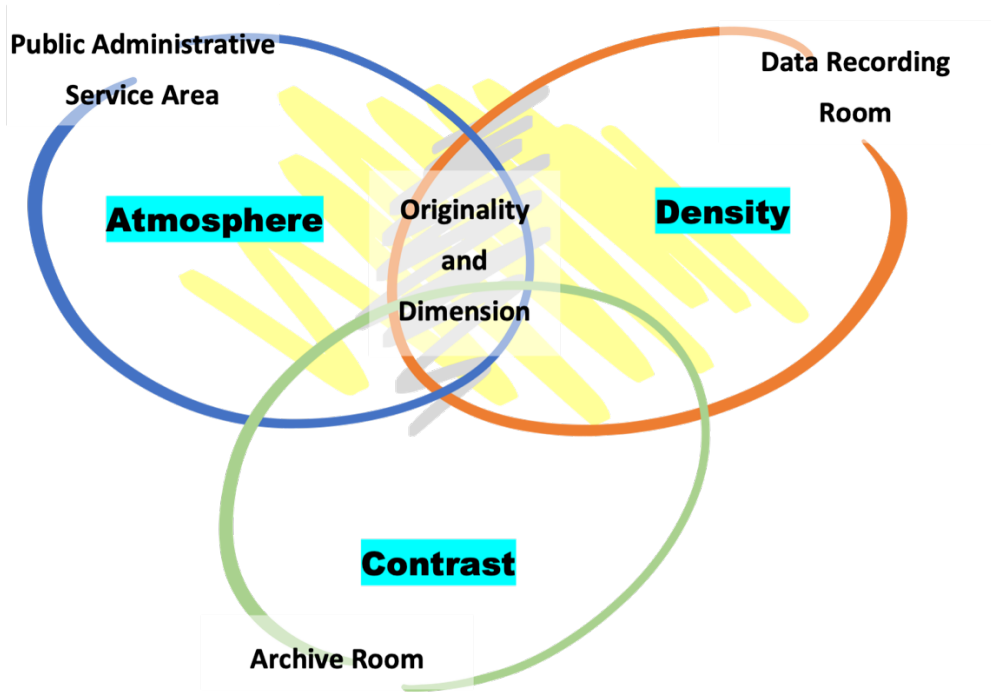


Figure 3: The position of the findings in the concept of one's self-defence in space.

In static environments like the archive room, originality and spatial dimensions ensure efficient document management and navigation. Each workspace has unique elements supporting its primary functions, such as the atmosphere in the public administrative service area, which emphasises workers' comfort while serving clients. In the data recording room, density becomes crucial, reflecting the need for efficient document

organisation. Meanwhile, contrast plays a dominant role in the archive room, facilitating the classification and identification of documents.

Exploring these elements reveals that no element is entirely exclusive to a single space. However, each unique aspect contributes significantly to the needs of its specific environment. Understanding these dynamics

enables the design of workspaces that enhance productivity and support workers' well-being. Seven key elements in workspace design significantly influence workers' functional and cognitive needs, shaping optimal work experiences and supporting their well-being. This connection is evident in the universal overlap, which includes consistent factors such as spatial dimensions and originality, reflecting a remarkable degree of flexibility that is crucial for fostering productivity. Despite the varying dynamics of stimulation in different spaces, when workers recognise an environment as familiar—like their daily workspace—and appreciate its comfort, their likelihood of remaining in that space increases.

In contrast, some elements show a partial overlap. These adaptive factors adjust to both the space's functional requirements and the workers' cognitive needs. This cognitive direction includes density, atmosphere, contextuality, and emotions. The conditions within the space and the workers' circumstances heavily influence these factors. Unique elements that bind to a space identify the cognitive attachment to its functions. For instance, in an administrative setting, individuals are likely to stay longer if they perceive the atmosphere as positive. In a data recording environment, workers can maintain better focus if the space is not overly crowded, leading to a higher probability of staying engaged. Conversely, contrast is crucial across all components in archive spaces, indicating its necessity for optimising the space to fulfil its intended function. Dynamic spaces, like the data recording room and administrative service area, support worker adaptation through emotional and atmospheric elements, while static spaces, such as the archive room, require optimisation for technical efficiency.

In this case study, a theoretical triangulation concept emerges, illustrating the close relationship between three primary elements: the workspace, the workers, and the phenomenon of pandemic fatigue. The integration of these elements reveals how multisensory stimuli and sensory overload impact an individual's resilience amidst complex sensory environments. Previous research has also indicated that the complexity of stimuli directly correlates with working memory performance, influencing an individual's ability to endure environments filled with sensory distractions ([Pusch et al., 2023](#)). This dynamic plays a crucial role in shaping workers' cognitive responses and significantly contributes to their overall experience of resilience in various spaces.

Three main factors influence the ability to endure: universal elements, adaptive factors, and those uniquely tied to the space. A humanistic and adaptive workspace design enables workers to interact more positively with their environment, reducing stress and enhancing their ability to adapt to challenges. In this study, workers are the primary subjects interacting with their workspaces while facing the challenges of pandemic fatigue. This fatigue affects their neurocognitive responses to environmental stimuli. Workers may experience sensory disturbances, such as heightened sensitivity to sound or light, impacting their performance and well-being. Therefore, understanding how workers process and respond to multisensory stimuli is key to designing supportive work environments.

The workspace, the workers, and pandemic fatigue interact in complex ways. Through multisensory stimuli, neurocognitive responses, and sensory disturbances, this interaction forms a triangulation that helps predict resilience in stressful situations. This triangulation illustrates why neuroarchitecture is crucial for designing adaptive and human-centred workspaces. Architects and designers can create work environments that promote physical and mental well-being by understanding the relationship between multisensory stimuli, workers' neurocognitive responses, and the effects of pandemic fatigue. Concluding the discussion involves: 1) integrating unique elements that meet individual needs; 2) recognising partial overlaps, which are relevant elements for specific groups; and 3) applying universal elements that benefit everyone.

With this approach, workspace design transcends mere aesthetics, focusing instead on supporting workers' adaptation to challenges, minimising potential fatigue and enhancing productivity. Neuroscience offers profound insights into the importance of recognising the workspace. The brain's principles in responding to multisensory stimuli in work environments align with Bayes' Theorem. A modified version of the theory suggests this: The more stimuli and sensory disturbances a person experiences, the less likely they are to remain in the space.

Applying this formula reveals that individuals can accurately recognise stimuli when the number of incoming stimuli is lower, thus reducing the likelihood of sensory overload. This research supports the development of multisensory integration in workspaces, aligning with previous studies that reveal sensory stimulation can enhance visual working

memory capacity, which is crucial for individuals' ability to recognise stimuli in their work environment (Pileckyte & Soto-Faraco, 2024). Looking ahead, the concept of workspace design that considers sensory stimulation aims to improve employee performance and well-being while reducing stress and fatigue (Sargent, 2024). Overall, these findings suggest that with the right sensory design, the brain can adapt to mitigate the effects of fatigue caused by pandemic-related stimuli, which is essential for fostering mental well-being in the workplace.

5.0 CONCLUSIONS

This research offers valuable insights into the relationship between sensory stimuli, individual cognitive abilities, and the experience of resilience in the workplace, particularly during the COVID-19 pandemic. The findings show that factors such as density, atmosphere, contextuality, and emotions adapt to align with both the functionality of the space and workers' cognitive processes. In administrative service spaces and data recording rooms, individuals are more likely to feel comfortable when it is not crowded (minimal density) and when workers' emotions are stable. Conversely, workers feel more at ease in archive spaces when the environment resembles its original state. The lowest persistence percentages reflect the opposite condition, revealing a high need for cognitive management. In the case of administrative service spaces, mental management is necessary to create an atmosphere within the space. In data recording rooms, cognitive management is needed by establishing the contextuality of the space, the mental management required in archive spaces by creating an atmosphere that supports comfort within the environment.

The results enrich the theoretical landscape of neuroscience and workspace design, offering empirical foundations for creating spaces that are aesthetically pleasing, functional and supportive of workers' mental health. As attention to employee wellbeing grows, this

research paves the way for further studies exploring various design elements, such as lighting, colour, and sound, and how combining these elements can be optimised to enhance cognitive performance and reduce fatigue.

The findings suggest that architects incorporate principles of experience formation, informed by neuroscience, into their design processes. This includes using adjustable lighting and sound control to create environments that support cognitive functions. Involving workers in the design process provides valuable insights into their needs and preferences. Surveys and focus groups allow researchers to gather feedback that can then be incorporated into the design. By implementing these recommendations, designers and employers can create workspaces that enhance productivity and support employees' mental well-being. Such environments become more adaptable and responsive to individual needs. This research emphasises that investing in effective workspace design directly supports workers' well-being and performance, highlighting the need for practical and actionable implementation.

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